abstract space

beneath the media surface

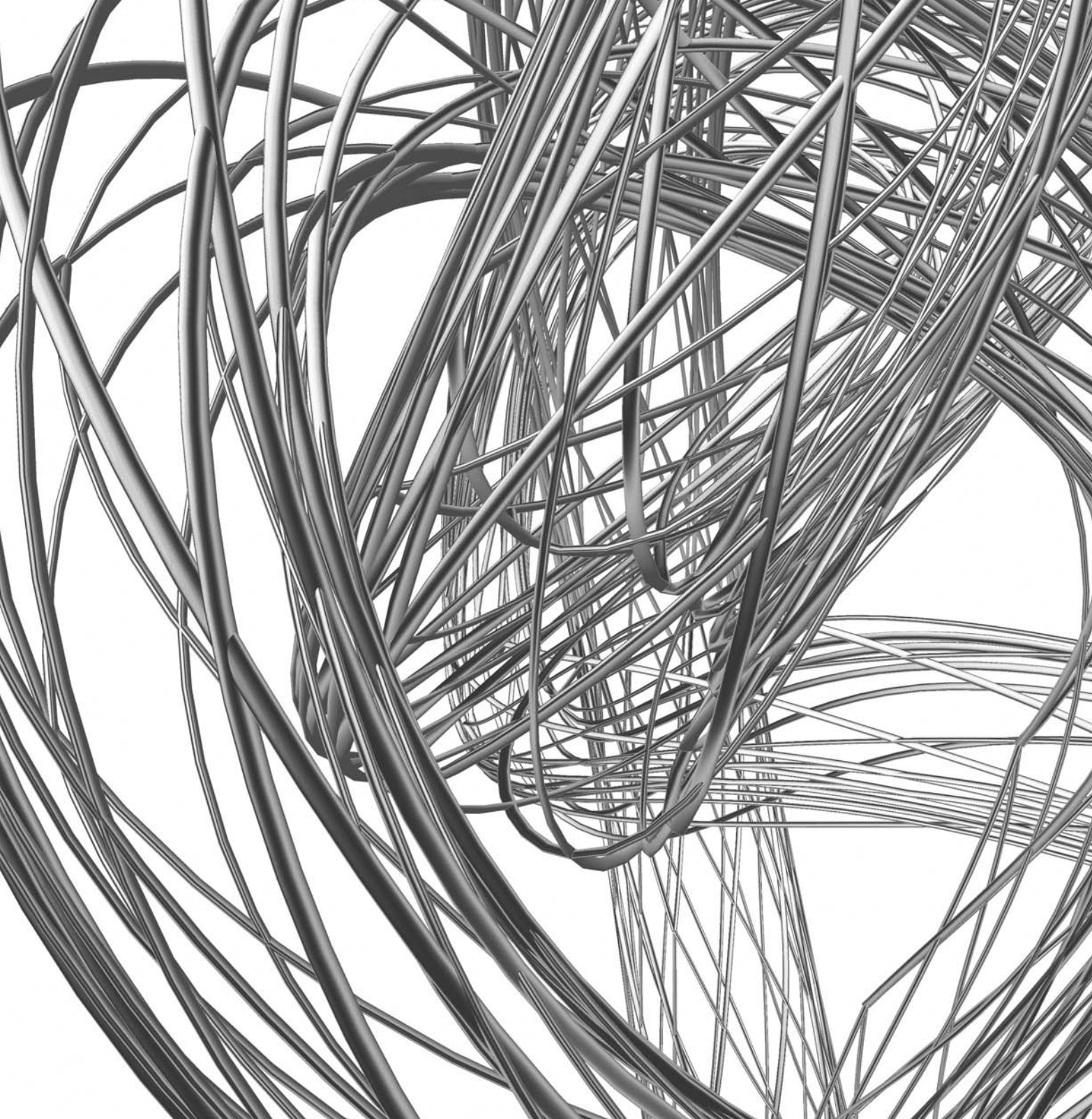
therese tierney

Abstract Space

Abstract Space: Beneath the media surface is a visually stunning and conceptually rich book which investigates the cultural connections between new media and architectural imaging. Notions of what the architectural image means today are explored through a range of material, from theoretical texts to experimental design projects. Within a design framework based on innovation and divergent thinking, *Abstract Space* engages discourses from architecture, visual and cultural studies, to computer science and communications technology. Also tracing a provisional history of the topic, the book lends a provocative and multivalent understanding to the complex relations affecting the architectural image today.

The author argues that the integration of digital methodologies into architectural pedagogy and practice have opened up an ontological crisis. The combination of new media along with advanced computing methods has destabilized the essential status of the architectural image-object, which was formulated much earlier in classical philosophical thought. *Abstract Space* demonstrates in both text and graphics that that architectural expression (of which the image is an important and powerful part) is not limited to one definition; it exists as a complexity and is variable. Today's architectural image operates not only metaphorically as a set of instructions, but quite literally, because the digital image is now underwritten in code. As an integral part of a design continuum, architectural expression has become intrinsically, though not exclusively, abstract, indicating a profound cognitive shift in how architecture is currently being realized.

Therese Tierney is currently a doctoral scholar at University of California Berkeley, where she is a Malcolm Reynolds Fellow. During 2005, she studied at Massachusetts Institute of Technology Media Laboratory, where she was engaged in design research on computational systems.



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Therese Tierney

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Introduction

This writing presents an exploration of design theories beginning at California College of the Arts under the direction of Mitchell Schwarzer and later developed during my studies at University of California Berkeley during 2002–2004 with Jean-Pierre Protzen, Dr. Eleanor Rosch, Ken Goldberg and Anthony Burke. These interests led to my subsequent research at Massachusetts Institute of Technology with John Maeda and Henry Jenkins III.

Recent advances in digital technology and communication have necessitated a new and critical appraisal of new methods of visual image construction as they relate to architectural production. Digital methods, primarily software appropriated from the entertainment and industrial design sectors, have destabilized the essential status of the architectural image-object, formulated much earlier during classical philosophical thought. Western European art experienced similar crises during the shift from Byzantine to Cartesian representation in the fifteenth century, and with photography in the late nineteenth century.

By the mid-1990s new methods of digital imaging, as well as technologically derived media, supported a more diverse means of expression for architects. Computational modeling techniques, e.g. scripting and simulations, adopted from the sciences, further contributed to an unprecedented dematerialization of the architectural image-object. Evolutionary form-generating software had transformed the architectural image into event and performance, either by understanding architecture as the epigenesis of spatial conditions, or by the object being conceptualized as the actualization of built-up potentials. Additionally, the current popularization of the Internet and wireless technology pressed architects to recognize new forms of public interaction, which traditionally had always been the provenance of architecture. Inevitably, architects began designing and giving form to this provisional territory.

Within architectural design the digital image operates not only metaphorically, as a set of instructions, but quite literally, because the image is underwritten in code. Architectural expression becomes intrinsically, though not exclusively, abstract. This conceptual terrain describes not only a mode of thinking, but also a mode of production, because designs are engendered through their imaging techniques. The operational component transforms the ontological nature of the image because the digital image as such resists any fixity of its contents; it exists as part of an ongoing realization of an architectural project. The resultant architectural image is therefore an index or residual of a process. As part of a design continuum, the digital image is not simply the formalization of thought into spatiality, but a modal continuum of divergent expression laden with potentiality.

Architectural expression (of which the image is an important part) is not limited to one definition; it exists as a complexity. From this perspective, it also seems necessary to constitute a notion of a complexity formulated on performatives. Perhaps one of the best examples is this book. What is it? A book could be described by its physical properties as a material object. It can be quantified by what we can measure, see, and touch. The thesis is 8.5"x11"x1". It weighs about four pounds, is composed of sheets of processed bleached wood pulp product, and was printed with a variegated pattern of black ink. One could even say that the ink patterns are graphic translations into a textual form of contemporary English language.

However, this description says nothing about the concepts inherent in the book, nor of the work that went into creating it or of the many contributions of others that went into producing it. As an alternative to the physical definition—that is, what the book is made of or even what it represents—one could ask instead, *What is it that this book does?* Let us examine it in terms of its operative relations. A book is portable, accessible; it opens up a terrain of investigation. It makes connections. Each reader will respond to it differently; it metamorphoses and forges new concepts outside the book. We can say that a book is not a static object, but a dynamic, ever-expanding set of relations.

Furthermore, although not visible, one could map relations, activities and intellectual linkages of research that took place in many cities and colleges over many years: people, films, journals, conferences, music, exhibitions, conversations, friendships, and chance encounters. This continual exchange of concepts and intensities inheres within a larger flow of experience. In actuality, this mapping of relations is not merely the resultant production of a book, or even the ideas contained in the book, but instead is the entire field of relations that the book encompasses as the nexus of a vast set of investigative

activities. Within this network of connections, some relate to the production of buildings, others to the social practices informed by buildings, and still others to the abstract desiring world of architects without which there would be no architecture at all.

Just as quantum physics revealed that observed results are linked to point of view, so this inquiry also attempts to examine the same theoretical phenomena from different points of view, because no one perspective is sufficient for understanding the transformation of the architectural image. If the concept of the book is a network, then the form of the book is expressive of this larger concept. Therefore each chapter can be read individually as a nodal point, or chapters can be linked together in random or linear succession. The book is structured multi-modally; that is to say, the images describe a narrative of their own, which is almost, but not quite, parallel to the text. Like a rhizome, the whole is composed of multiple registers from which any multiplicity will connect to other multiplicities. Each chapter creates its own trajectory, which may lead the reader to form his or her own conclusions.

This book challenges the reader toward an investigation of—or, more accurately, an experimentation with—the contingent object of architecture. It requires the reader independently to test theories of individual, collective and social reality. It is hoped that this construction will produce connections of unrealized potential yet inconceivable at the time of this writing.

METACITY LAGOS-LOOP

J DANNENBERG
C SHUSTA

01 POPULATION
SITE
PEDIGREE
TEXTURE TYPE

LAGOS LOOP 02
KIT OF PARTS
MEL CODE
DESIGN STATS

The 1991 census of Nigeria puts the population of Lagos at 5,685,781. However, this figure is widely discredited because many of the city's inhabitants returned to their villages of origin during the census. Extension to the United Nations and the Lagos State Regional Master Plan put the Lagos' current population at about 10.0 to 15 million inhabitants, composed largely of the country's three main ethnic groups: Yoruba, Ibo and Hausa.

This figure makes Lagos State the most populous state in the Nigerian Federation. With its area of 3,577 sq. km. the smallest in the country, the state's population density of 1,590 persons per sq. km. is remarkably high. The densely value for built-up metropolitan Lagos, estimated at 20,000 persons per sq. km. is even higher still. A 1986 estimate indicates that the population of Lagos State had been growing at an annual rate of 8 per cent in the urban areas and 3 percent in the rural areas. According to UN projections, population will reach 19.9 million by 2010.

Lagos' remarkable population growth signifies the need for an urgent architectural response. As Lagos' eco-guards no-sense as does the potential for the city's expansion to occur horizontally, especially considering available land and construction techniques. The consumption of land we nonetheless the erosion of farmland with natural reservations that are critical to Nigeria's food and tourism industries. So to address these concerns this scheme proposes a residential skyscraper situated over Lagos' Tinubu Square roundabout. In lieu of the standard design process, this strategy engages the roundabout via generative, borrowing its cycle and velocity to script a looped computer modeling code that builds, erodes, and organizes an infinite number of skyscraper possibilities, from which some per a formal pedigree varying in texture and performance.

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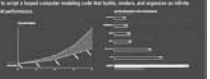
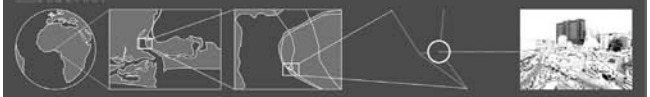
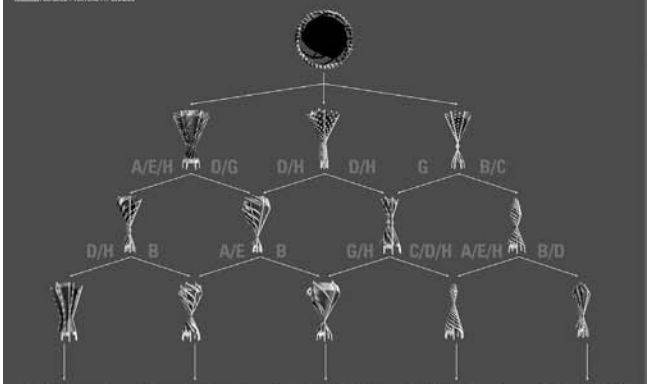
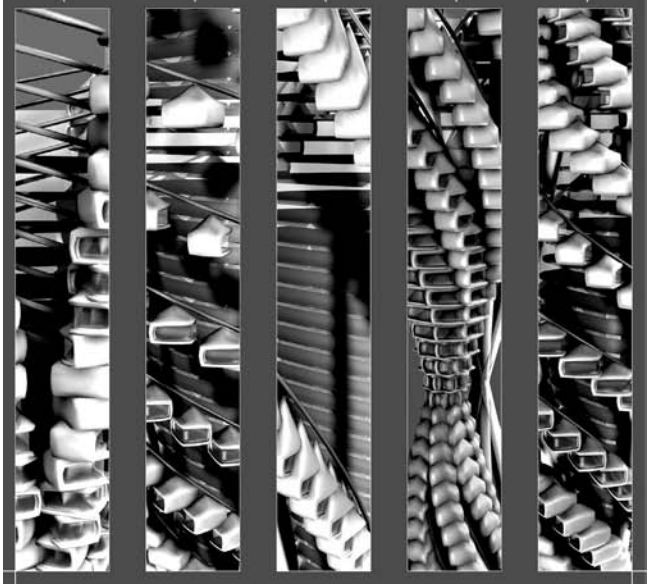


LAGOS, NIGERIA, TINUBU SQUARE



PEDIGREE + TEXTURE TYPOLOGIES





1
Architecture + abstraction

Topologies of new media

1.1
Joshua Dannenberg and Chris Schusta: *Metacity Lagos-Loop* (2006). Harvard Graduate School of Design 2311, Fall 2005, Instructor: Kostas Terzidis
With computational technology, *Lagos-Loop* accelerates the design process by engaging mass amounts of data while providing strategic and efficient infrastructure for the city. The Loop suggests that building design is a generative process and that code can play a powerful and effective role in shaping metropolitan infrastructure.

In the practice of architecture today, the adoption of computational methods has irrevocably changed the way buildings are conceived and assembled. Three-dimensional CAD models can be exchanged between networked computers or distant consultants; drawings are created in different time zones and are modified without ever leaving the digital sphere.[1] Global technology is shaping the architectural discipline into a distributed, multidisciplinary, and collaborative profession responding to a rapidly changing telecommunications industry. These alterations within the profession have been occurring with such rapidity that their theoretical implications have yet to be fully realized.

The introduction of digital methods into architecture has challenged its normative design practices in complex and unanticipated ways. Twenty-five years after the computer entered the architectural profession, not only has the design context changed, but so too has virtually every aspect of production. An architectural project using manual or analogue design methods is very different from one created by computer-aided design. As a result of new technologies, digital techniques—otherwise known as new media—have altered both the epistemological and the ontological status of the architectural image. New tools and techniques allow us to question the status of the image; this questioning has serious consequences because the architectural image describes both a mode of thought and a process of information exchange.

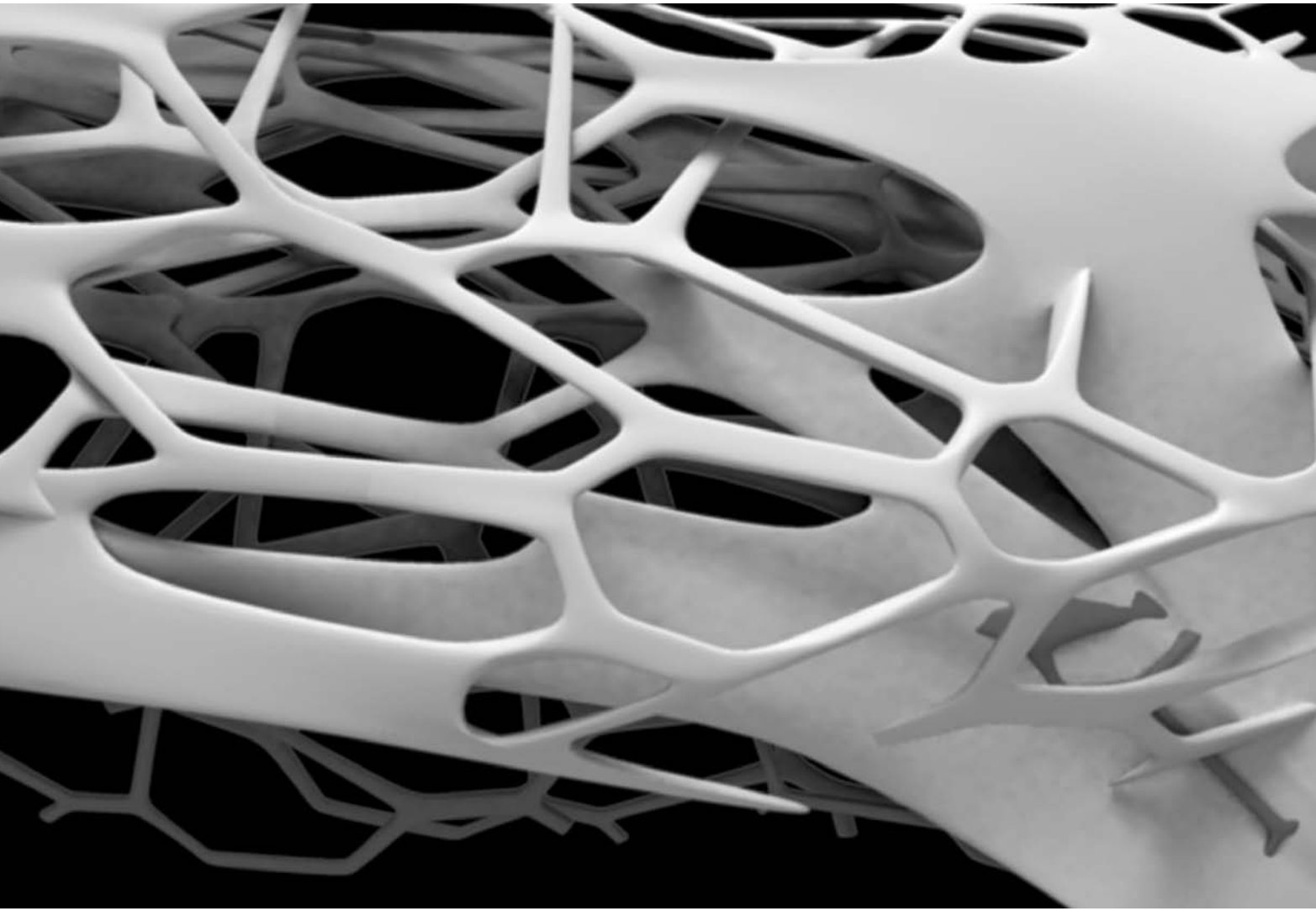
The term 'image' in this case will be used to describe architectural drawings, whether analogue or digital, photographs, renderings, animations, or new media. The transformation is due to the fact that the architectural image now operates within a field of complex, interactive, and continually changing relationships involving cognitive abilities, social forces, and technological modes of expression. Furthermore, according to cultural critic Paul Virilio, technology inevitably delivers a hybrid.[2] The resultant hybridization of the architectural image has destabilized not only formal design strategies, but also the meaning of the architectural image itself.

1.2
Shelly Eshkar and Paul Kaiser: still from *Pedestrian* (2002)
A digital public artwork and computer-generated animation of urban circulation patterns.

With this transformation of the architectural image comes a methodological crisis in the architectural field: a crisis that calls for a considered judgement of the origins, nature, and possible consequences of the crisis. More particularly, this book is an act of criticism that contributes to the construction of a social theory and philosophical practice that may assist understanding of new media's effect on the architectural image, the architectural design process, and the architectural field in general. As a beginning, the relationship between conceptual architectural thought and digital media expression will be examined.

An essential part of this examination is the displacement of traditional aesthetic principles for judging architectural images. This would include not only conventional one-point perspective and orthographic projection (plan, section, and elevation), but also the broader conceptual assumptions related to permanence. By these fixed definitions, these inherited notions have inhibited our understanding of the transformation of architectural expressions. Instead of the traditional static approach, I intend to propose a dynamic relational approach that treats architectural design as a process of information exchange. In adopting this method, I will be relying on investigations of thought and perception made by cognitive scientists and philosophers during the late twentieth century.

In order to understand the extent and depth of alteration in the architectural image, it is necessary to recognize the multiple registers of architectural production. There is always another medium beneath the material media in which architectural design is realized, and that is, first, the medium of symbolic programming language, and then, second, the medium of architectural thought. During architectural production, a concept or idea moves from one level of realization to another, each one involving a different mode of translation or perceptual turn, each a transformative moment in the concept's or idea's realization. The passage of the concept or idea through these various registers constitutes a dynamic space, both influencing the architectural design process and allowing for the production of new architectural forms.



1.3
Jun Yu: *Forms of Cellular Aggregation* (2005)
SCI-Arc 2GBX Studio
Instructors: Marcelo Spina, Peter Testa
Software: GENR8 by Emergent Design Group/MIT

Such a dynamic conception of the space of architectural design and production is crucial to any investigation of new media's effect on the architectural image. If, however, we consider certain inherited notions from the past—Plato's classicism[3] or Heidegger's phenomenology,[4] for example—we find not a dynamic, but a view of architecture and space in which buildings were viewed as idealized, static objects located in fixed space. The architectural image itself was a representation of the stability of that space. It spoke to permanence as if to negate the passing of time. From the image's etymology dating back to Roman times, an *imago* was a portrait or bust carried aloft in funeral processions. The *imago* was indexical, linked to death, to the marking or the memorial of a singular moment.[5] Robin Evans developed this notion further in his explication of the origin of painting in *Translations from Drawing to Building* (1997). There he describes the story of a woman, Diboutades, who traced the profile of her departing beloved as a means of preserving his memory.[6] From these examples, one could surmise that originally images were connected to something that had passed, whereas today images speak more to life and biological processes.

It was this memorialized view of architecture and space that limited our understanding of the transformation of the architectural image. Digital technology's impact on architecture was originally framed and bounded by the limitations of analogical modes of perception. In architectural practice, most computer applications were used initially for the production of construction documents: data entry and output, as well as project organization. Digital methods were deliberately defined as merely documentary or representational. Later, however, as increased processor speeds and more extensive random access memory became the norm, it was increasingly apparent that the new technology could offer a different formal design strategy. Concurrently, three-dimensional digital modeling programs continued to be refined and soon created a highly articulated difference in the quality of conceptually constructed space.

1.4
Greg Lynn: *Embryologic House* © Installation (2002)

1.5
Kai Zhang: *The Ship of Dreams* (2002)
Digital animation

Media theorist Marshall McLuhan ventured that social change always precedes technological change;[7] or as Gilles Deleuze phrased it, "Machines are social before being technical."[8] Therefore one could speculate that the adoption of digital methods exhibited a desire among architects to achieve a more complex understanding of space, requiring a more complex means of expression. Beginning as early as the 1970s, but most particularly in the late 1980s and early 1990s, experimental architects had appropriated software from other design disciplines, primarily from industrial and product design—automobile, aircraft, and shipbuilding, as well as communication technologies—in order to test these new methods of form-making.

The appropriation of industrial design aesthetics and methods was not without precedent; earlier in the twentieth century Le Corbusier had admired the streamlined functionalism of ocean liners and racecars.[9] Today, however, what industrial design offers architecture is a range of digital methods and software, including *Catia* for digital scanning, and CNCmilling (computer numerically controlled machinery) for digital fabrication. Numerous architectural firms, such as SHoP in New York and Morphosis in Santa Monica, have merged 3-D modeling programs with a systems-based design approach. Currently, architectural propositions are being designed and constructed that would have been impossible without the use of computers; examples include projects by Renzo Piano Workshop, Future Systems, Nicholas Grimshaw, and Tom Wiscombe of Coop Himmelb(l)au, among others.

It is important to note that, with few exceptions, such as Buckminster Fuller or Archigram's futuristic propositions, the field of architecture in general was skeptical of highly technical solutions. By the late 1990s, however, southern California had emerged as a site of experimental digital architecture. Not coincidentally, it also happened to be the nexus of the entertainment industry, aerospace engineering, and automobile research. Architects, notably Frank Gehry, benefited from the technology transfer of advanced computing software from private research institutions: Lockheed Martin's Advanced Development Programs, along with Honda, Nissan and Toyota research facilities. With regard to contemporary visual regimes, the larger shift occurred through a bottom-up infection of architecture by digital culture. Computer-Generated Imagery (CGI) and animation disseminated through mass media, film, music videos, video games, and advertising inevitably infiltrated architectural modes of seeing and design.

What is significant is that the appropriation of software from the entertainment industry infused architectural designs with a previously inconceivable potential for animated transformation and movement, evidenced first in the introduction of a temporal dimension to design, and, second, in more complex topologies. This was achieved through a transition from vector-based design to a more highly delineated curve. A more complex programming code, NURBS or Non-Uniform Rational B-Splines, allows the manipulation of curves and surfaces through their control points. The resultant form may then be altered with innumerable variations without changing the entire entity. NURBS makes the heterogeneous yet contiguous forms of digital architecture computationally possible. Originally, graphic design was composed of lines defined by points in space drawn on a plane; now the methods of computer-generated modeling operate on a virtual three-dimensional entity endowed with motion potential. Thus the architectural image has been radically transformed from a two-dimensional, static representation to a protean, three-dimensional, mobile construction.

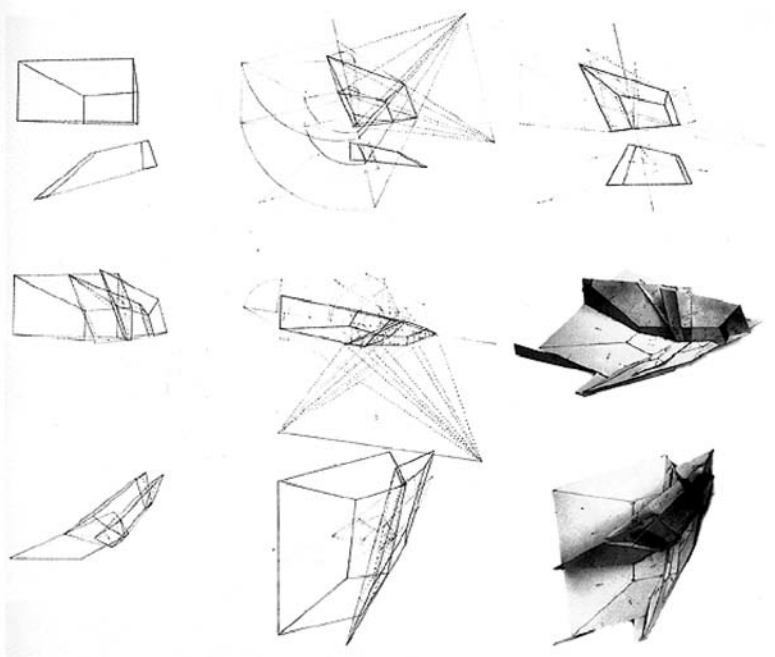
The traditional definition of the architectural image excluded any relativity between time and space; that is to say, a static image was an immobile, temporally fixed image. In actuality, all forms that exist in space also unfold in time, and conversely, forms that develop in time will simultaneously reveal themselves in space.[10] Moreover, with animation software, time was relative, as it could now be manipulated in both its sequencing and its duration.

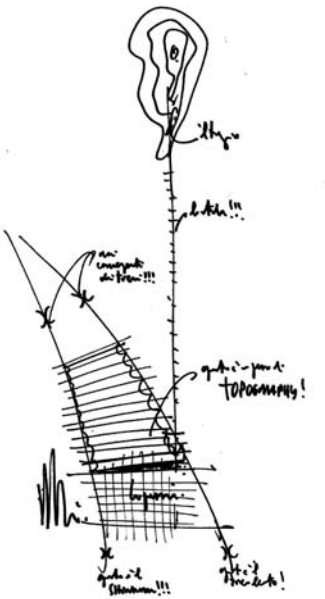
Materiality
Analogue drawings, like photography, are in continuous tone, whereas digital material is generated from code. When translated onto a graphical user interface, this results in individual pixel units describing a complete image.

Geometry
The object of the descriptive process has changed from a two-dimensional, orthogonally projected surface to a variable three-dimensional virtual space, from a planar to a spatial matrix.

Translatability
The same digital construction or file can be translated into multiple graphic platforms or media, including web documents, with infinite scalability and without any interim steps.

Movement
A digitally constructed entity has animate potential; the introduction of the temporal dimension necessitates a perceptual shift from object to event, from space to time.[11]





1.6 (left)
Preston Scott Cohen: *Stereotomic Permutations* (1994)
Projection model sketches

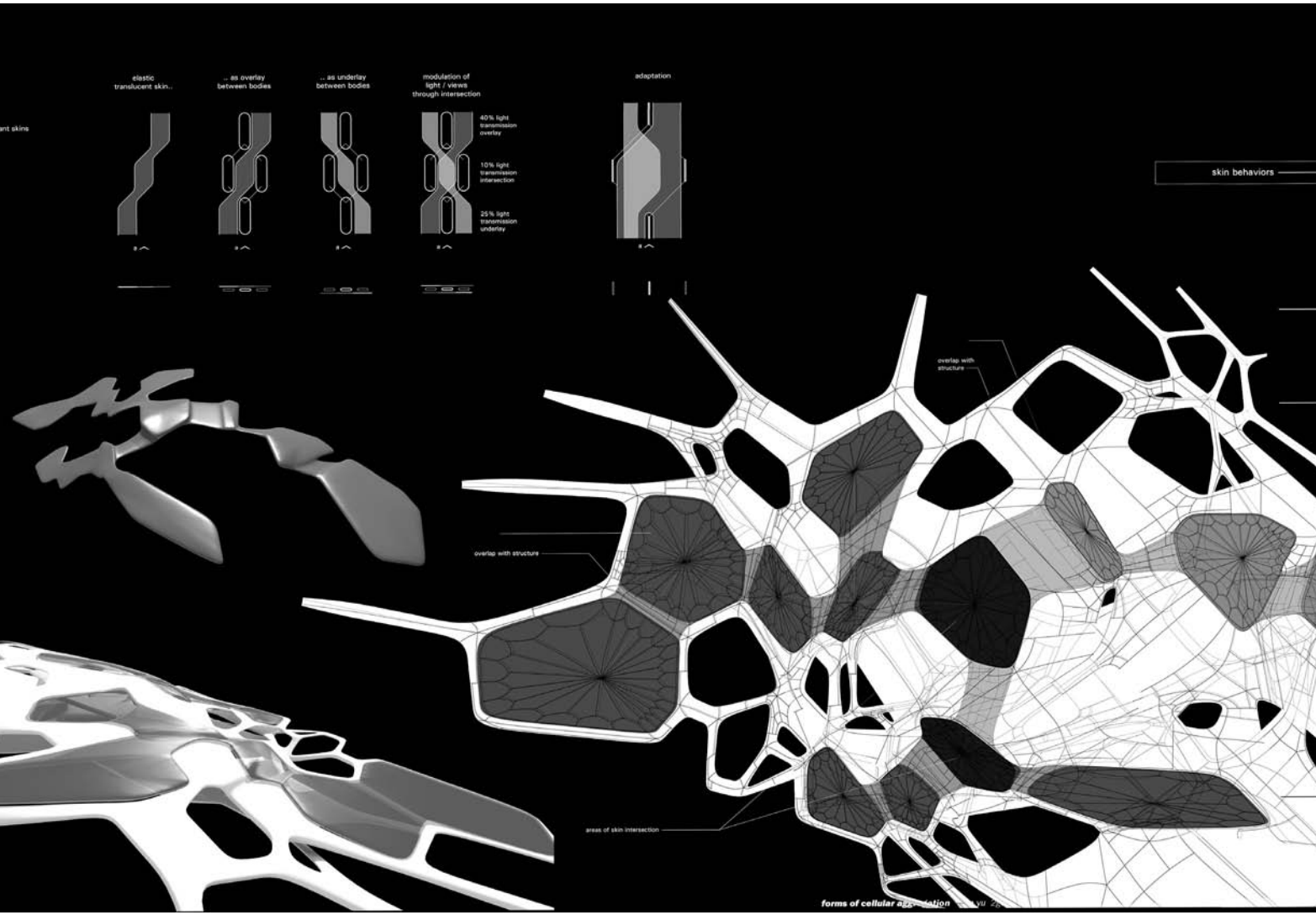
1.7 (right)
Renzo Piano, Renzo Piano Building Workshop: conceptual sketch for multifunctional arena competition, Saitama (Tokyo), Japan (1995)

As a result of these ontological differences, the architectural image is being destabilized; and along with it, its metaphysics. If the analogue image was a representation of something that already existed or could have existed but now is considered part of a conceptual process or an investigation, then we are left with contingency, instability, and uncertainty.

Let us then examine individually the characteristics listed previously. Analysis reveals that transcoding is a slippery signifier because the same digital file can be expressed multimodally. The most recent techniques not only assist in the virtual forming of architecture, but also bring out the heterogeneous behavior of the digital material, according to Manuel DeLanda:

> Form is no longer something static imposed on the outside on structure with homogeneous properties or a behavior that can be assimilated by the characteristics of solid modeling, but is rather influenced by the properties of the tools used, under the form of the singularity of the digital material. Therefore, it brings out the generative processes and their possibilities connected to the concepts of interactivity, modifiability and evolution among the principals.[12]

In an elaboration of Second Generation design research theories, Horst Rittel concluded that design explorations are never complete.[13] In a similar manner, digital material or code offers a new medium of formal expression each time the code is translated. During the design process, an idea is inevitably translated into different digital media or software platforms, with a new perception created at each step, providing opportunities for unexpected ideas to surface. This results in a multiplicity of viewpoints more closely resembling conceptual or cognitive space. In fact, a multiplicity of perceptions enables designers to understand spatial relations with more complexity and to analyze possible solutions with more efficiency than was previously possible with analogue methods. Studies on the cognitive processes of designers reinforce the conclusion that nonlinear operations are typical; multimodal shifts, collaboration, and testing of ideas are an essential part of the architect's conceptual design process.[14]


elastic
translucent skin..
.. as overlay
between bodies
.. as underlay
between bodies
modulation of
light / views
through intersection
adaptation
40% light
transmission
overlay
10% light
transmission
intersection
25% light
transmission
underlay
skin behaviors
overlap with
structure
overlap with structure
areas of skin intersection

1.8
Jun Yu: *Forms of Cellular Aggregation* (2005)
SCI-Arc 2GBX Studio
Instructors: Marcelo Spina, Peter Testa
Software: GENR8 by Emergent Design Group/MIT

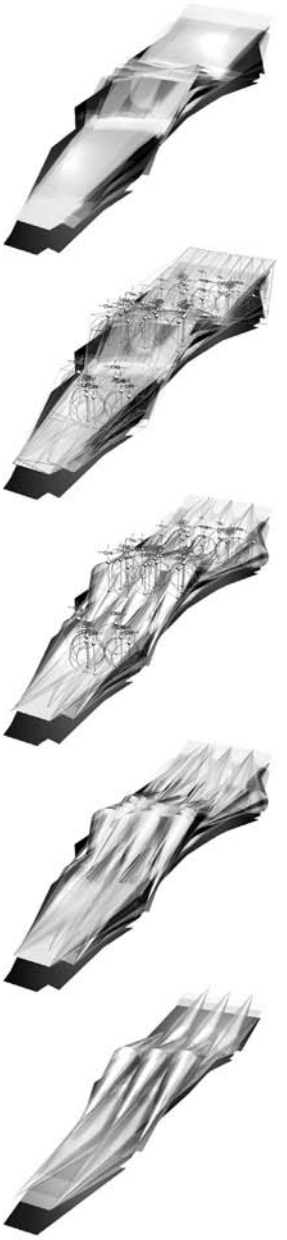
Contrary to both Robin Evans's and Walter Benjamin's concern that translation is always accompanied by loss, with new media there is none because there is no "authentic form to be copied, only the ongoing realization of the architectural image."[15] Translation becomes merely a point of view, and not an action on the object. Therefore, any loss or degradation must be framed within a discussion based on development, change, or growth derived from the context of emergent design methods.

As such, the architectural image, while remaining an inherent and integral part of the design process, has changed its ontological basis from representational trace to organism, from a two-dimensional static document to a three-dimensional entity with animate potential. Conceptually, this metamorphosis occurs during architectural form generation, through the imposition of parameters or constraints at various stages whereby a given proposal may then generate any number of variations through algorithmic processes. Instead of one idealized image, this results in many potential morphologies.

Theoretically, parametric design processes, as an interrelation or organization of parts within a flexible complex entity, employ an evolutionary approach combined with computational strategies. This theoretical moment of joining has a history of elaboration in terms of the notion of the virtual. In Walter Benjamin's work, the virtual is a description of language as a tendency toward expression.[16] In Henri Bergson's work, the virtual is "becoming-other," a question of duration and motion. For those who address the virtual in the manner of Benjamin and Bergson, the virtual is not a matter of nonmaterial spatial illusion, but describes a process of self-differentiation.[17]

If architecture is now contingent, uncertain, unstable, it is because the image, which was once conceived as fixed, now exhibits differentiation or change. Media theorist Pierre Levy also suggests that the virtual distinguishes itself from the possible through a movement of becoming-other or heterogenesis. If an entity becomes-other, it then must be outside the realm of predictability. This is important, because it challenges our logical assumptions of causality. Can an ordered structure incorporate unpredictable change, differentiation or becoming-other? I suggest that through movement, through differentiation, an ordered structure can alter itself. Therefore, a static or fixed description will no longer suffice. This also precludes the definition of the virtual as an entity, much less as an illusion. If the virtual becomes the virtual through movement, it is more accurately a process. As Samuel Weber states, "the nature of the virtual is so constructed that actualization signifies differentiation for it."[18]

1.9
Achim Menges:
Evolutionary Computation and Artificial Life in Architecture (2004)
Software: GENR8
Architectural Association

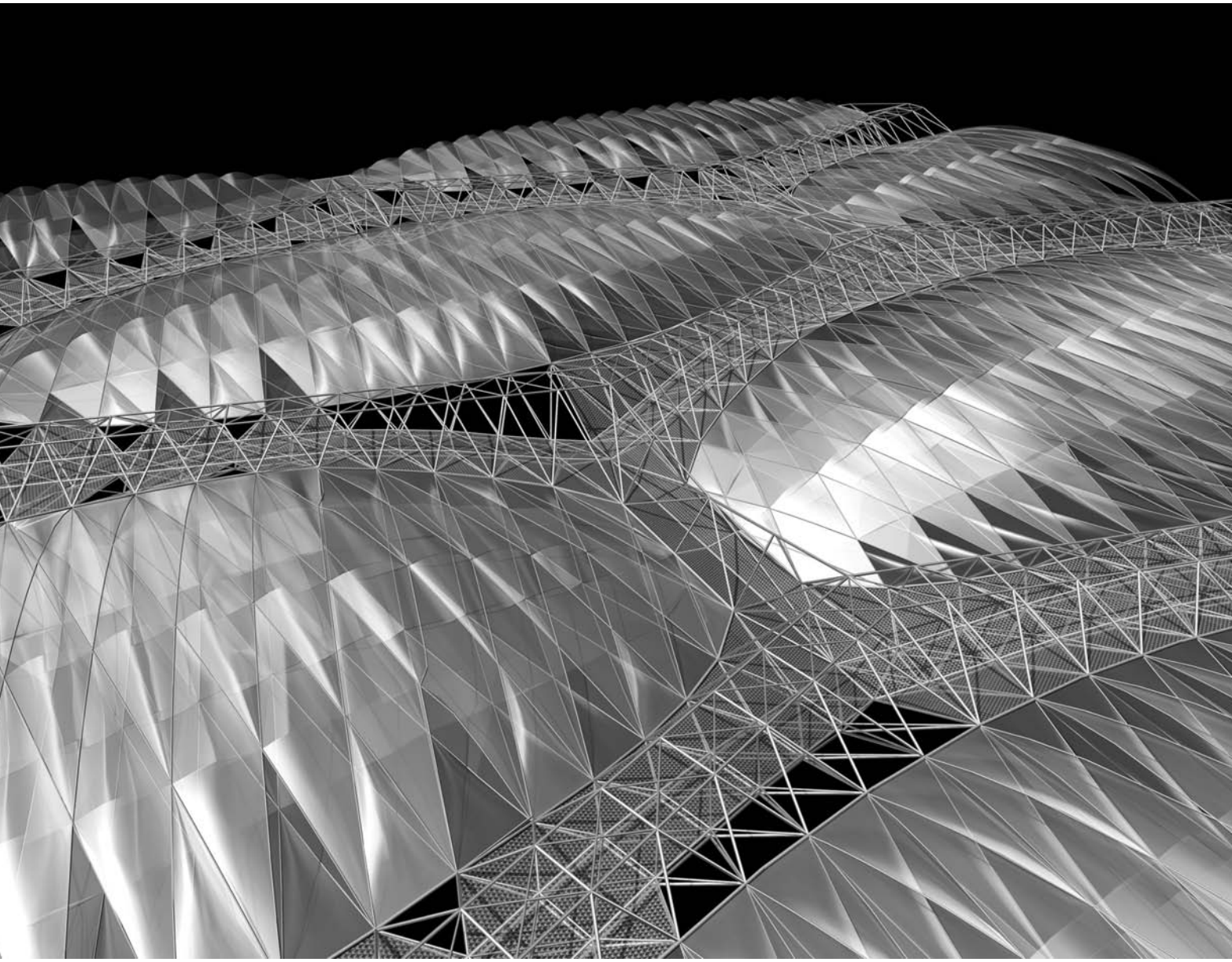


Embedded within the virtual structure, each actualization signifies differentiation. This leads me to agree with Deleuze in that the virtual is veritably creative. Intellectual thought, innovation, and design all actualize through differentiation; they are all generative processes. Yet these examples can only be viewed as generative when seen through the operations of time. Within the concept of structure must then be embedded a temporal characteristic, one that could incorporate change, growth, and differentiation over time, being neither static nor binary. In addition, within the virtual, the potential for complexity and randomness would have to exist. To be more precise, in lieu of Levy's *heterogenesis*,[19] I would like to introduce the term *cosmogenesis*, or making worlds, to describe the process of the virtual because it addresses the tendency toward differentiation.

At present, the digital *is* an interface between cognition and expression. With the integration of digital methods, primarily through new media's animation software, it is possible to view design acts not only as an ongoing process within a larger continuum but potentially as ends in themselves. As substantiated in DeLanda's writing, form is always subject to its own internal process, so always becoming.[20] Actualization may not be necessary, or even possible. This stands in contrast to historical views that examined the architectural drawing as a material artifact (albeit a product of social forces).

1.10
Achim Menges:
Postagricultural Project
(2005)
Software: GENR8
Architectural Association

Walter Benjamin, in "On Language as Such and on the Language of Man," questioned the notion that language was defined only by its use-value.[21] Is the architectural drawing defined only by its use-value, by its function as a static artifact? As an alternative, if the architectural image is defined as a conceptual process or as part of a design continuum, it is possible to accept the notion of an uncertain architecture. I would venture that what is intrinsic to the architectural image might exist outside its functionalism. Instead, it is the image's abstract tendency toward differentiation, toward information transfer, that is contextual and responsive. This process of unpredictability, "what we don't know yet," is most inherent to the design process. It is an expressive becoming-other that defines the architectural image. This, then, is perhaps the crucial work of architects: the becoming-other of something that, although real, has not yet come into being.[22]



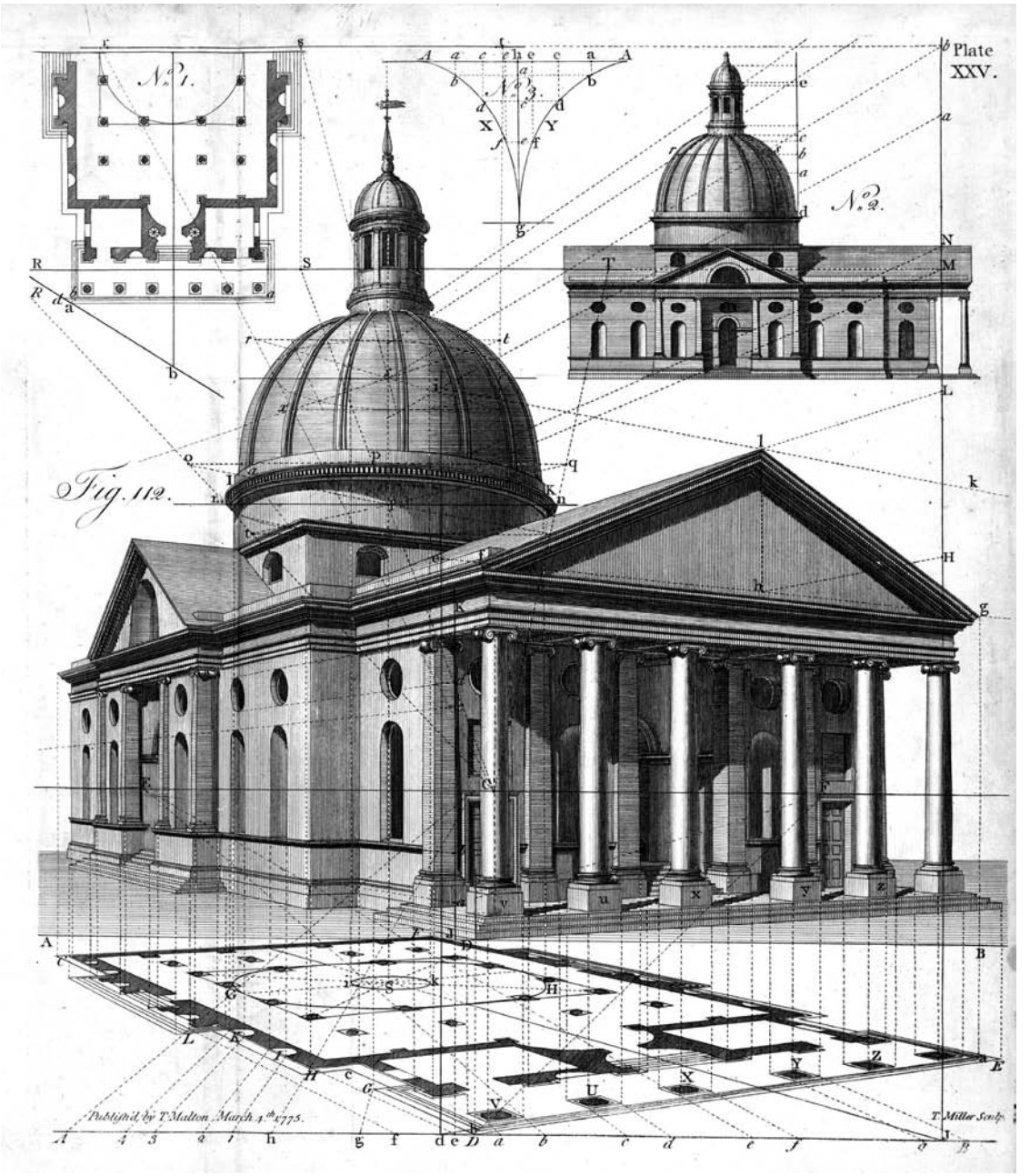


Plate XXV.
Fig. 112.
Publish'd by T. Malton March 4th 1775.
T. Miller Sculp.

2
Architectural modes of seeing
Visual theory and technologies

2.1
John Malton: Plate XXV, *Plates on Optics and Perspective* (1775)

Buildings are often born of images and live on images.
Spiro Kostof[1]

If we acknowledge that complex social forces and unpredictable technological innovations have worked together to produce a transformation in today's architectural image, what would a genealogy of the process look like? While architectural pedagogy encompasses the pragmatic requirements of design and building technology, it also includes speculation on the act of building: in other words, thinking about architecture. Therefore any examination of the image would require an analysis of visual theory because the digitally produced architectural image exhibits not only a method of construction, but also a mode of perceiving, which is to say, a theory behind the method.

While visual instrumentation falls within the larger pattern of the advance of the sciences and technical rationality, both are inseparable from the history of communication technology. It is through *technos* (technology) that the *medium* (or mode) for ideas to be communicated or translated was established. As was witnessed with Galileo first, then with Leon Battista Alberti, and today with new media, each advance creates a perceptual paradigm shift.

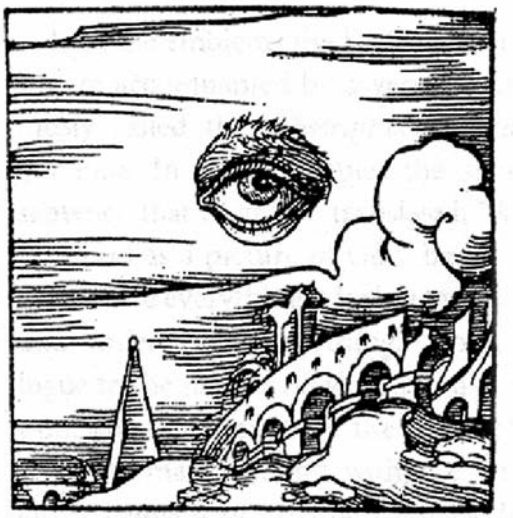
Architectural design is, at its most basic level, a conceptual activity. As participants in a creative discipline, architects are engaged with the production of ideas. From a prescient diagram on sketch paper to a hyperrealistic computer rendering, architects construct concepts through visual means of communication. It is not surprising that architects throughout history have been inextricably linked to visual regimes and their resultant reality theories, from the camera obscura and Karl Frederich Schinkle's panoramas, to theaters, video games and computer-generated special effects. Even contemporary digital modeling software traces its provenance back to Renaissance norms and methods of seeing. These viewing regimes and methodologies are neither momentary nor hermeneutic, but instead continue to shape our view of the world and the social relations within it.

While we can say that vision is socially constructed, we must also ask upon what ground. Prior to digital media, the experience of external vision was a reflection of something real or actual in the world. Even photography and film relied on a direct reflection of light from a physical object. However, new viewing regimes linked to digital technology are more immaterial than in the past. Additionally, mass communication and the Internet cross language barriers, so that vision has evolved into the primary sense of the postindustrial era, with the visual image evolving as the lingua franca of a global market economy. Within architectural practice and pedagogy, it may be unequivocally stated that more architectural ideas are currently disseminated through the visual media and text, photographic images, Internet websites, and videos, than through any actual buildings or structures. Of still greater import, however, might be that architecture's historical certainty and veracity have been destabilized through new media's competing notions of dematerialized space.

In order to map out the implications of these digital trajectories, it is necessary to survey the shared territory between visuality and architecture. Within the context of a postindustrial, postmodern culture, history's ability to contribute effectively to the understanding of new technologies has been challenged. Yet what this challenge fails to recognize is that whenever a new technology is invented, it results in a paradigm shift within discursive relations. Until recently, architectural history was typically studied as an adjunct to art history. However, the reordering of art history via postcolonial theory led to a reframing of the discipline within a broader framework of visual studies, which is concerned with all forms of visual expression, including popular culture and the formation of subjecthood.[2] One of the primary demands that visual studies places upon architectural theory is to understand the epistemological basis of Cartesian space and its cognitive implications on the viewing subject.

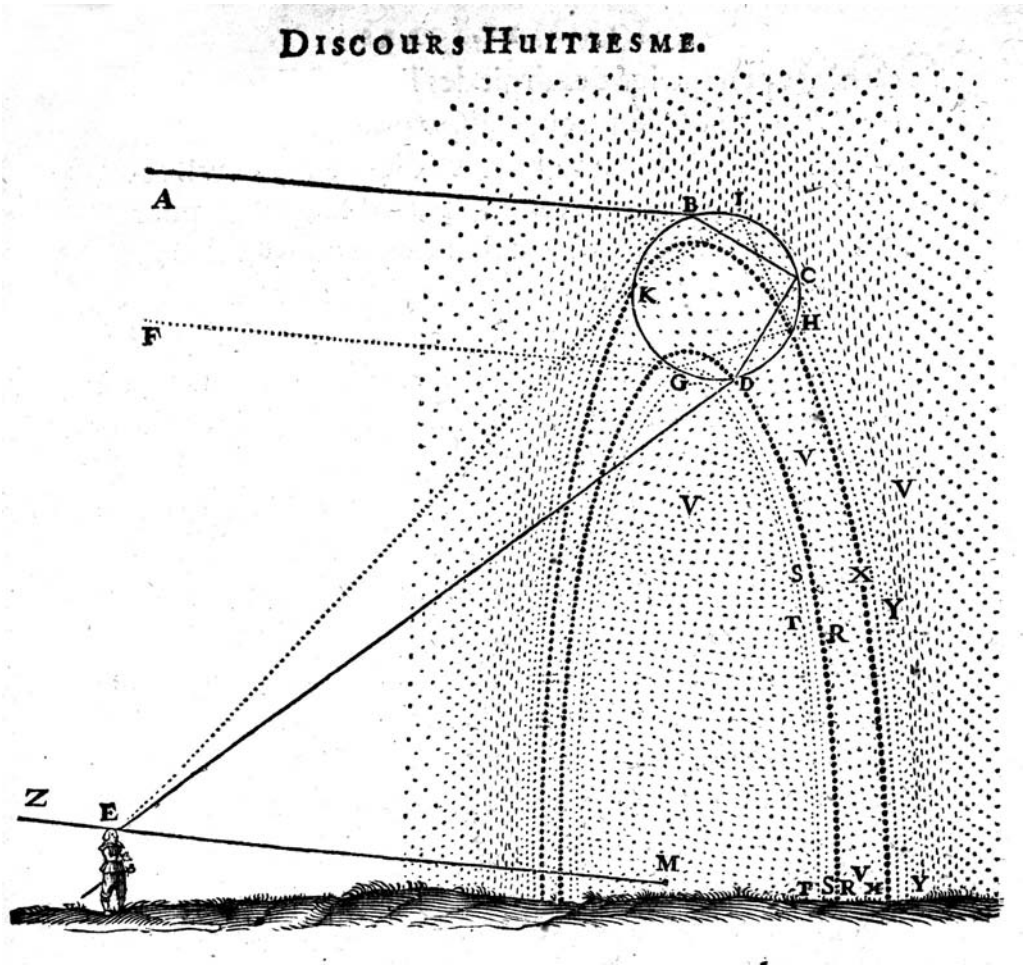
2.2
Quo modo Deum
(17th century)

ORI APOLLINIS



Quo modo Deum.

Oculo picto Deum intelligebant, quòd vt oculus quicquid ſibi propoſitum eſt intuetur, ſic omnia Deus cognoſcit ac videt.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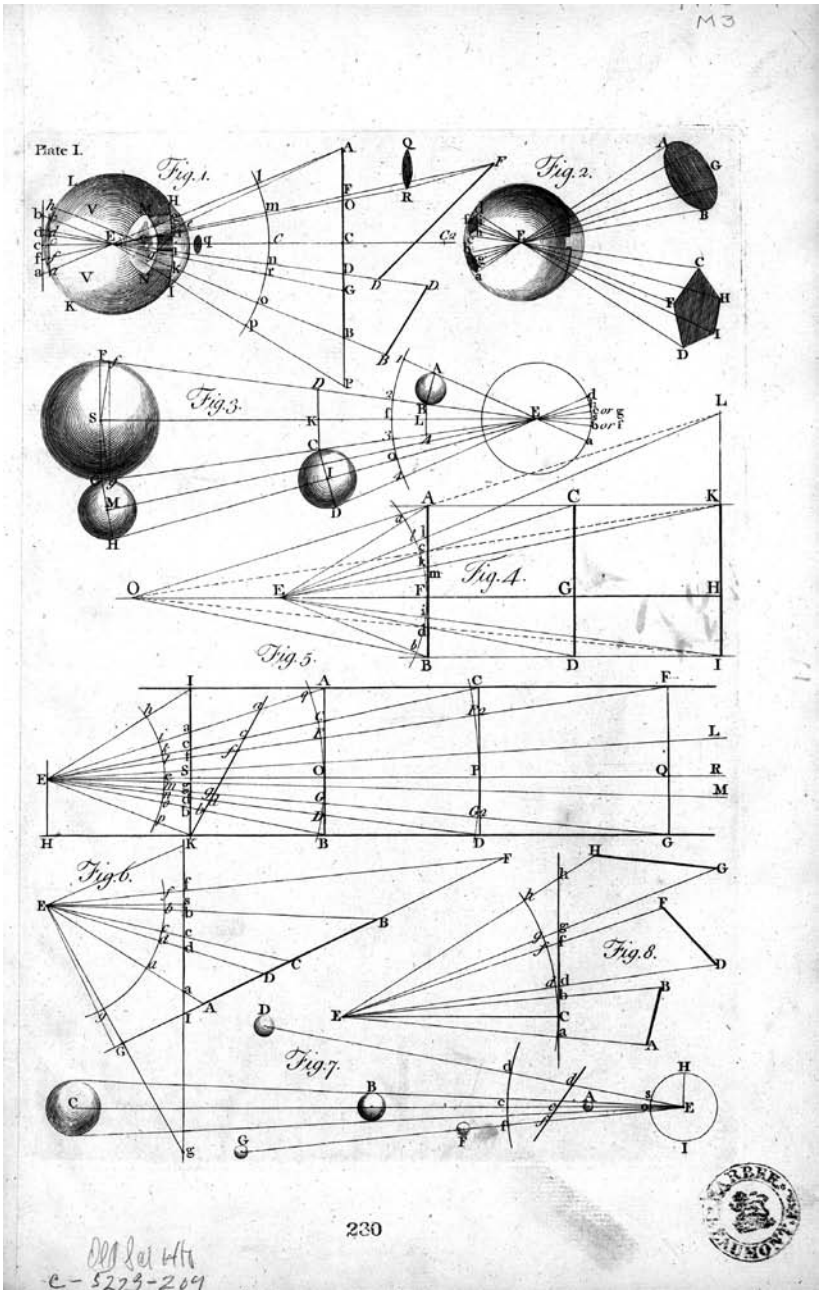
2.3
René Descartes: Optical field, *Discourse de la méthode* (1637)

This demand is not insignificant. The epistemology of Western European visual theory systems has had serious moral and physical implications. Iconoclasts such as Galileo and Thomas Cranmer risked forfeiting freedom or life for such concepts.[3] Ideological shifts do not occur without a struggle, as J. L. Heilbron chronicles in *The Sun in the Church*. In 1632, Galileo's crime was simply an accurate description of an observation made through his invention, the telescope. He was forced to recant, forbidden to teach or write, and sentenced to life imprisonment. While the Church removed a challenge to its geocentric view of the world, humanistic rationalism continued to thrive, as expressed through scientific innovation of the eighteenth century, which instrumentalized and institutionalized modes of looking.[4] These social and technological shifts were embedded within the architectural treatises and discourses of the time, and have continued to inform our thinking today.

From the Renaissance era's linear perspective to today's computer special effects, the apparently separate disciplines of architecture, visual perception, and media technology have shared the same philosophical territory. It is not coincidental that the same names, notably Plato, Kant, and Descartes, appear and reappear in treatises on philosophy, visual theory, and optics. In the last few centuries, visuality has also been increasingly linked to how we define the real. Yet in its exclusion of other senses that are normally associated with direct bodily contact—touch, taste, and smell—this new "reality" is less physically complex than its predecessor.[5]

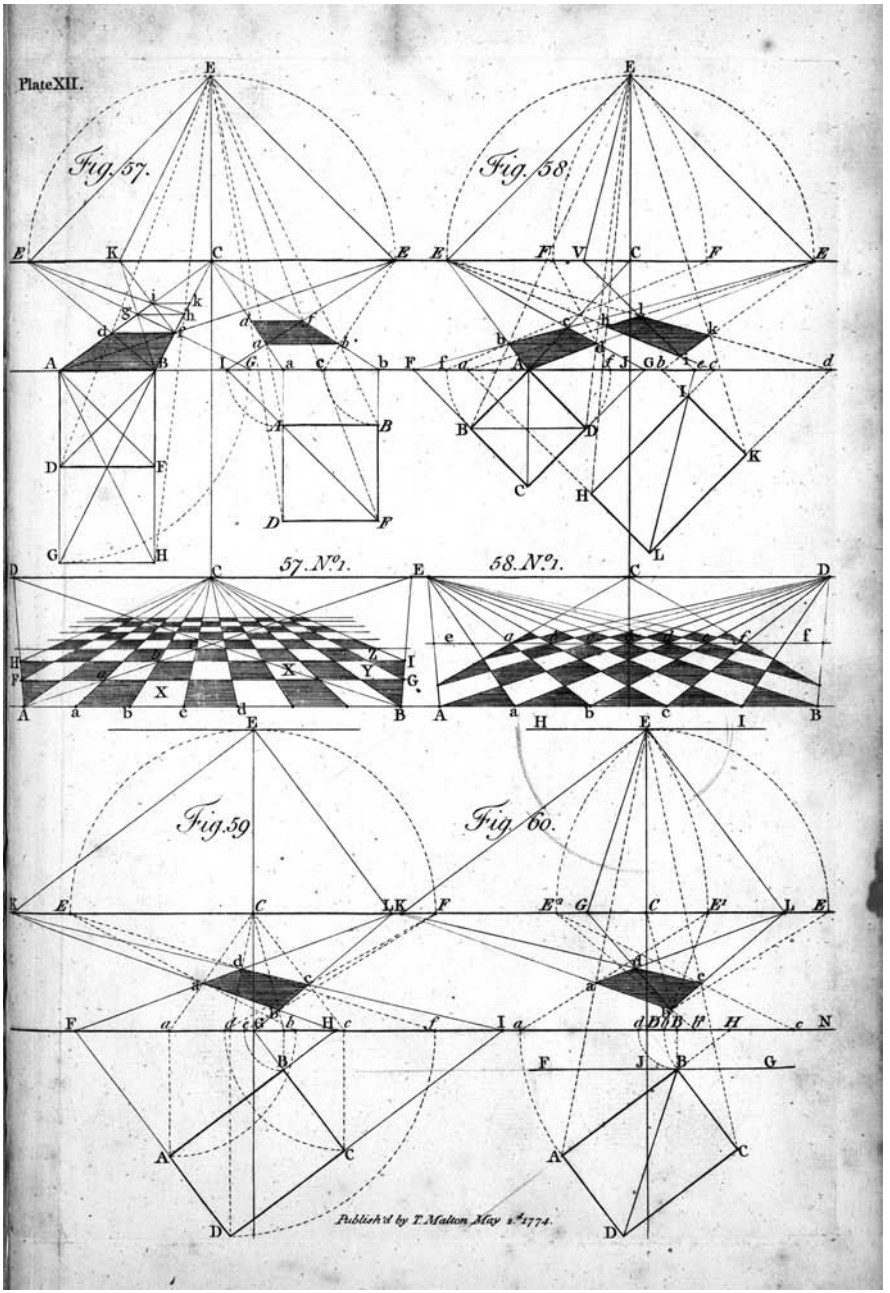
To the neuroscientist, it is not surprising that vision should be chosen for this enhancement. Neurological studies have consistently proved that vision has always been the predominant sense in human cognitive interpretation of experience. Research at the University of California Berkeley revealed that a higher percentage of brain functions are dedicated to visual perception than to any of the other senses. In addition, their studies concluded that humans prioritize vision over the other four senses. In repeated experiments, when conflicting stimuli existed between touch and vision, the brain overrode the tactile sensations and assigned veracity to sight.[6]

We can conclude that the way we perceive or see informs the way we think, because the mode of instrumentalization frames our perception. If we are to consider the architectural image "with our eyes open," architecture's visual history will need to be deconstructed. And while it is a common misconception that historical facts exist hermetically sealed in a box, historical beliefs are, on the contrary, so deeply embedded within our knowledge-formation systems that they form unspoken assumptions about the ground of architectural expressions.



2.4
John Malton: Plate I, *Plates on Optics and Perspective* (1775)

2.5
John Malton: Plate XII, *Plates on Optics and Perspective* (1775)



Received notions

Architectural theory can trace its origins to the earliest inception of classical thought. Philosophical writings established a divisible hierarchy between abstraction and physical expression, termed property dualism.[7] Over the centuries, this duality winds its way though all forms of art discourse, including architectural theory, which succinctly describes it as the "mind/body problem." The architectural discipline integrates both abstraction and physical expression as design and structure. In a similar fashion, visual theory also inherited the same philosophical framework: sight is a property of the mind and linked to the intellect, but the eye is a physical sense organ.

Plato was one of the earliest to venture the premise of another reality behind the world of appearance. His ideas negated the primacy of the five senses and spoke instead of a mind not subservient to sensory input. Within this hierarchy, however, Plato considered vision the noblest of the senses, as it was the least physical—a bias that still continues today.[8]

Vision is never experienced directly; it is understood that we do not see the sense object, but only a reflection of light from the object. Plato further believed that, through mimesis, the world could be abstracted into a language of color, form, and line. By having an affinity with geometry, these abstracted qualities were then privileged over direct experience. Thus Western philosophical thought, as epitomized in Plato's writings, structured a binary and hierarchical separation between mind and body, between thinking and lived experience, between abstraction and materiality.[9]

As a subsequent development of visual theory, Plato then proceeded to create the earliest intellectual structure related to knowledge formation by assigning hierarchical positions to both visuality and architecture within ancient Greek pedagogy. Because architecture's role within the academy has long been a contingent one, these inherited notions merit review.

During the first century BC, the Romans further developed the Greek categories of education and knowledge. Knowledge production, as determined by classical thought, was defined as "aesthetic appreciation, without reason or utility."[10] Roman categories described science and art, in addition to philosophy and mathematics, as acceptable forms of knowledge. Architecture, as one of the technical arts insofar as it was directed toward some external necessity, was, along with painting and sculpture, not included because these disciplines required physical expression and consequently were considered lower forms of endeavor.[11]

During classical times, architect–builders and artisans were landless. Within a society where land could be neither bought nor sold, but only inherited, for the most part architect–builders were either itinerants or slaves.[12] In ancient Roman and Egyptian culture, artists and craftsmen/builders were basically nomadic; they relocated, with their families, from project site to project site. Without access to formal education or training, artisans and builders learned the skills of their trades from within the family unit as they moved from site to site. Even more important, unlike that of the landed noble, the artisan's identity was not fixed to a particular villa or village. Instead, both the literal as well as the metaphysical ground of his being was located within the particular project he was working on at the time.

If we attempt to trace the definition of architecture through the social structures of the past, it was much later, not until the thirteenth century that the Mechanical Arts were eventually added to the canon of Liberal Arts, which still meant, "existing in the mind."[13] *Trivium* included verbal thought and language arts, and *Quadrivium* included number construction. Mechanical Arts included architecture, navigation, medicine, theater, and agriculture—all pursuits accomplished with the hands as opposed to purely intellectual activities. As established by classical definition, any of the Mechanical Arts therefore served a function or purpose (necessity or *utilitas*); unlike mathematics, they were not considered intellectual pursuits. More importantly, in practice, these divisions not only served as a method of organizing knowledge, but also functioned operationally as a means of class definition and control.

Visible thinking: Descartes' legacy

The hierarchical structure of intellectual or professional knowledge continued through the Middle Ages up to the time of the Renaissance. However, this social positioning was about to realign itself with the rise of humanist thought. Leonardo da Vinci's and Brunelleschi's visual experiments, in addition to Leon Battista Alberti's writings, ventured a new method of seeing known as Renaissance perspective.[14] Not wishing to duplicate Jonathan Crary's extensive research on the topic, let it suffice to say here that Renaissance perspective systems required a single point of view (or reference point); they were based on the quantification of information, and required measurement.[15]

Aside from a move to render objects (in space) more "realistic," this analytical method of positioning objects in space was an attempt to elevate architecture from a craft to an intellectual activity by equating it with a mathematical system. One begins to see efforts to socially construct an artist–architect as one who thinks/contemplates as opposed to one who merely uses his hands or builds.[16] This was a concerted effort among architects to position their profession in such a way that the invisible work, the thinking, could be made visible.

One can also see that the architectural method of expression became fused with an artistic method, since many artists were also architects, and vice versa. The development of communication and graphic expertise—drawing, painting, sketching—became as important as the actual building. Pragmatic concerns, then as today, called for a realistic rendering that enabled a client to visualize a project before committing funds. During the fifteenth century the technical and, more importantly, the visual aspects of architecture came to be associated with the medium of design.

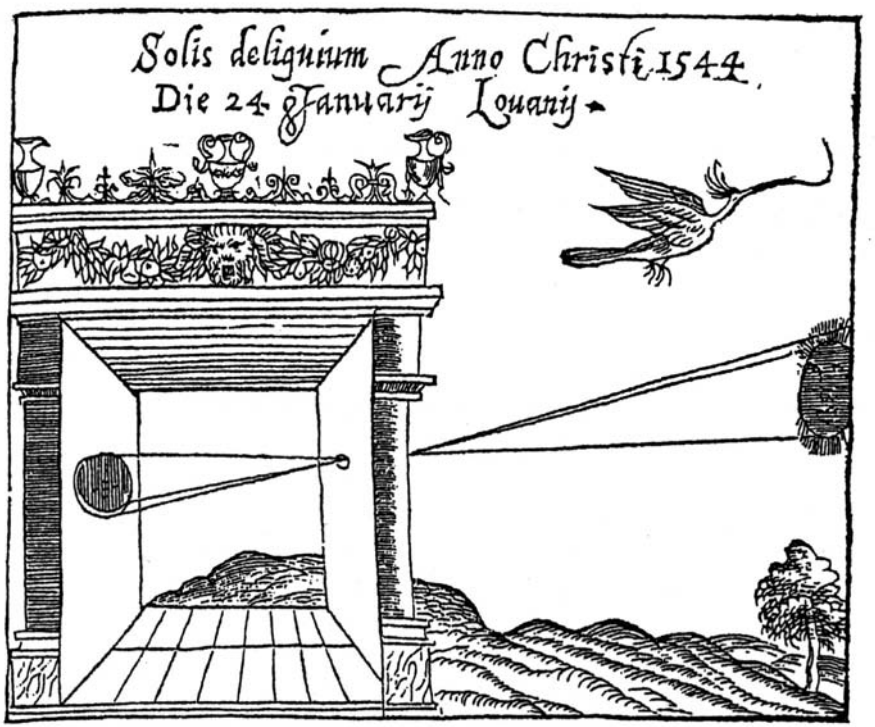
These notions were disseminated through architectural treatises during the late Renaissance, primarily Alberti's *On Painting* and *On the Art of Building*. Architecture's alignment with a quantitative visual ordering system spatially privileged a Cartesian rationality derived from one-point perspective, which is to say, one way of looking at the world. The viewing apparatus of perspective also worked on the assumption that space was inherently static, that it existed as a background or substratum for geometrically described objects fixed within it. The architectural image therefore was a representation of the stability of that space, and in turn exhibited a reassuring certainty against the anxiety caused by the loss of a divine worldview. This fixity not only evolved into what became accepted as normative vision, but also quantified objects and even people as objects. Sight was thus defined, measured, and instrumentalized by the scientific world.[17]

Yet how did Renaissance perspective come to be associated with the Cartesian duality between mind and body? The Cartesian conception of the subject extended its influence through all forms of cultural production. Certainly painting, in its continual attempts to portray reality as closely as possible, unquestioningly adopted this new drawing technology because of the perceptual accuracy of perspective. When rational humanist thought replaced a divinely ordered universe, the loss of center could also have suggested that the center was dependent on the position of the viewer (the subject). The gaze through a mathematical frame, as it were, was secular, static, unblinking. It was a reductive gaze with an abstract coolness that signified a detachment of the viewer's emotional response. This was a rational, examining gaze rather than a passionate glance or stare of wonder. As an unexpected result of the architect's desire for intellectual and social elevation, space became quantitatively conceptualized.

Camera obscura: the Northern vision

During the seventeenth century, an alternative vision to Cartesian perspective was being formulated based on a similar desire to more accurately represent reality. While scientific discoveries were contributing to rationalist views and Renaissance Italy was reformulating vision into a mathematical construct, the French scientist–philosopher Descartes made improvements to the camera obscura during his experiments on optics. In preliminary experiments with a cow's eye, Descartes came to believe that the eye—or rather, the mind—functioned in a similar manner to a camera obscura, in which light entered a box through a small hole and reflected an image upside down on the back wall, which was lined with white paper. The artist then traced the image to create an unmediated, direct, authentic, and realistic portrayal of the world. However, while direct in theory and actuality, its scope was still limited to views that could be framed by the pinhole—only a piece or a fragment of the world. In its own way, then, the camera obscura also quantified the perceptual experience.

If Vermeer's *The Painter and his Model as Klio* (1666–1667)—a Dutch painting of the same period—is analyzed, for example, the painting reveals, in addition to its geometric structure, a method of tracing similar to the action of the camera obscura, with the intention to document or map fragments instead of presenting a holistic or monolithic view. Note the various formal methods of representation portrayed by Vermeer: the map on the wall, the plaster bust, and the compendium of architectural drawings on the table, as well as the painting on the easel. These examples were descriptively rendered by closely examining the textures and surfaces in a phenomenological visual experience related to Bacon's philosophy. Light reflected off an object and then directed onto a paper was no


Solis deliquium Anno Christi 1544.
Die 24 Ianuarij Louanij.

2.6
Camera obscura
(16th century)

longer an interpretation or reconstruction; it was actually a piece of the world, a piece of reality captured and recoded. Therefore the perceptual attitudes of the camera obscura included empiricism, veracity, and objectivity. Foremost, however, was the camera obscura's highly representational mode, even more pronounced than that of Cartesian perspective, in that an artist–architect could only trace or represent what already existed in the physical world. It moved visual theory further toward establishing a belief system that only what could be seen or touched was real.

Considering past ideological shifts related to human self-perception, it was Galileo's simple observation through a telescope, leading to the scientific discovery that the sun, not the earth, was the center of the solar system, that resulted in a fundamental loss of the sense of a center—moreover, of even the idea of a center.[18] Renaissance culture was the first to have to deal with existential anxiety and fear of deception: in other words, that what is perceived is not necessarily real. Descartes' contemporaneous proposal that reality is in the mind, arguably made the center dependent on the position of the viewer (the subject). In lieu of a divinely ordered cosmos, Cartesian space, as a reality construct, was the means of providing certainty and solidity to a newly evolving rationalist viewpoint. So by the modern era, the subjective subject was quantified, gridded, and groundless.

The historical trajectory of the architectural image is inherently linked to developments in vision technology, which in turn are linked to knowledge production. Since technology is rooted in a desire for a quantifiable means of understanding phenomena, each new vision technology resulted in an additional method of measurement. Instruments that were initially conceived to measure or reconstruct reality in the world were then appropriated by architects as tools for constructing possible realities. A repeating pattern throughout history can be traced in which passive, reflective instruments for recording external reality later became active and productive within architectural practice. Technologies for registering an image-world then became instruments for envisioning architecture. As evidenced in the past, when imaging technology changes, so does its teleology. Each new technology delivers its own mode of perception, which ultimately frames and constrains the visions that are produced.

2.7
Jan Vermeer: *The Painter and his Model as Klio* (detail) (1666–1667)


chair (chãr), *n.* [OF. *chaiere* (F. *chaire*), < L. *cathedra*: see *cathedra*.] A seat with a back, and often arms, usually for one person; a seat of office or authority, or the office itself; the person occupying the seat or office, esp. the chairman of a meeting; a sedan-chair; a chaise[; a metal block or clutch to support and secure a rail in a railroad.

3
Formulating abstraction

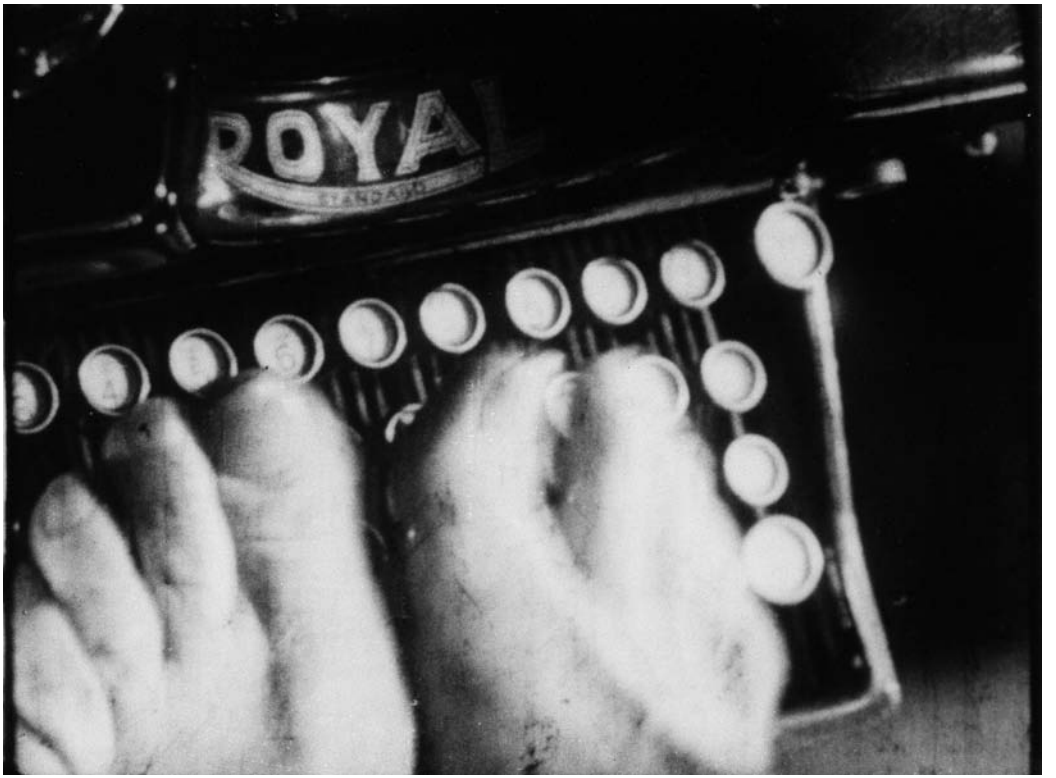
Conceptual art and the architectural object

3.1
Joseph Kosuth: *One and Three Chairs* (1965)

Imagination pouvoir
Graffiti in Paris 1968 during the student demonstrations[1]

In order for us to understand the intricacy of today's transformation of the architectural image, it will be necessary to extend our investigation beyond the architectural discipline itself and into the related fields of art and other forms of cultural expression. A period of questioning and critique occurred in Western art during the late 1960s, by examining this past we can gain an understanding of the challenges architectural representation currently faces a vis-à-vis to digital media. The forces contributed to the dematerialization of the architectural "object" are in many ways similar to those involved in the dematerialization of the art "object," that is to say, increasing attention to process and context. This philosophical shift can trace its origins back to the conceptual art movements of the 1960s and 1970s, when Clement Greenberg's argument for medium specificity had ultimately exhausted itself.

Any reconsideration of the architectural image has serious consequences, because the image instantiates not only a process of information exchange, but also a mode of thinking. In this case, the term "image" will be used to describe architectural drawings, whether analogue or digital, photographs, renderings, animations, or new media. While in the past a few visionary architects, most notably Giovanni Battista Piranesi (1745), Etienne-Louis Boullée (1784), and Antonio Sant'Elia (1914), had for varying reasons experimented with redefining architectural drawings as products or media, it is worthwhile reinvestigating art's response to technology's challenge of immateriality, which invites comparison with the current architectural discourse.

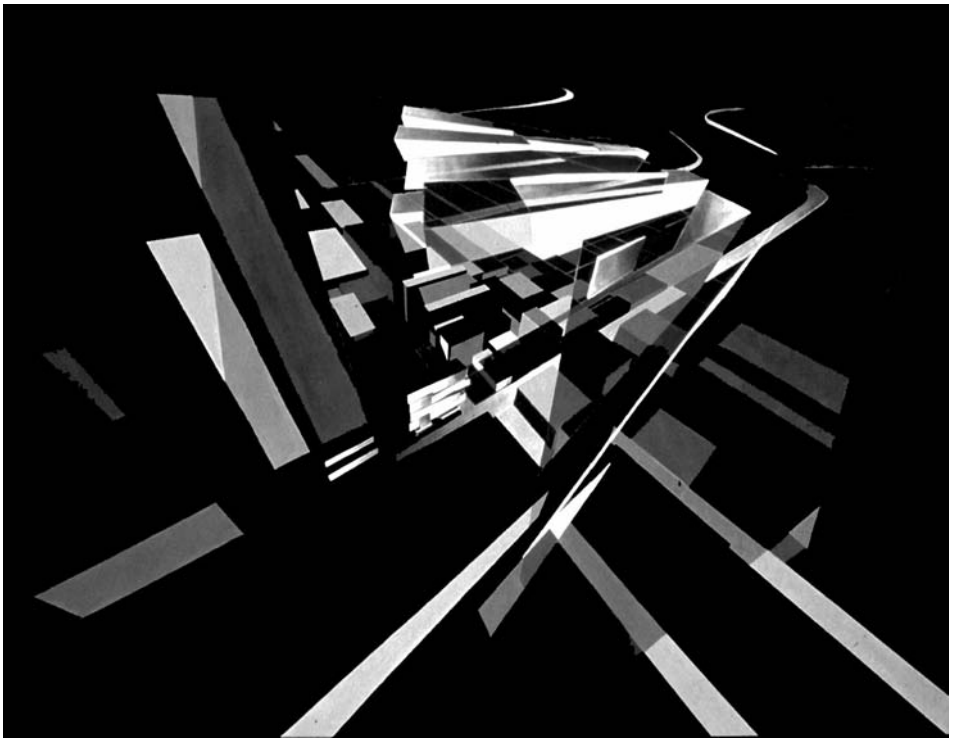

ROYA
STANDARD

3.2
Hans Richter:
Everyday (1929)
Dadaist film

During the early twentieth century, the normative vision of the fine arts was called into question because of numerous factors, but most especially because of technological advances in methods of representation, first by photography and later by Dadaist film. Both film (through movement) and conceptual art (through anti-form) necessitated a shift in thinking about what precisely constituted a work of art.[2] Questions were posed by critics and artists alike, all of which threatened to destabilize the art world: is art an eternal immutable object? a commodity? a process?

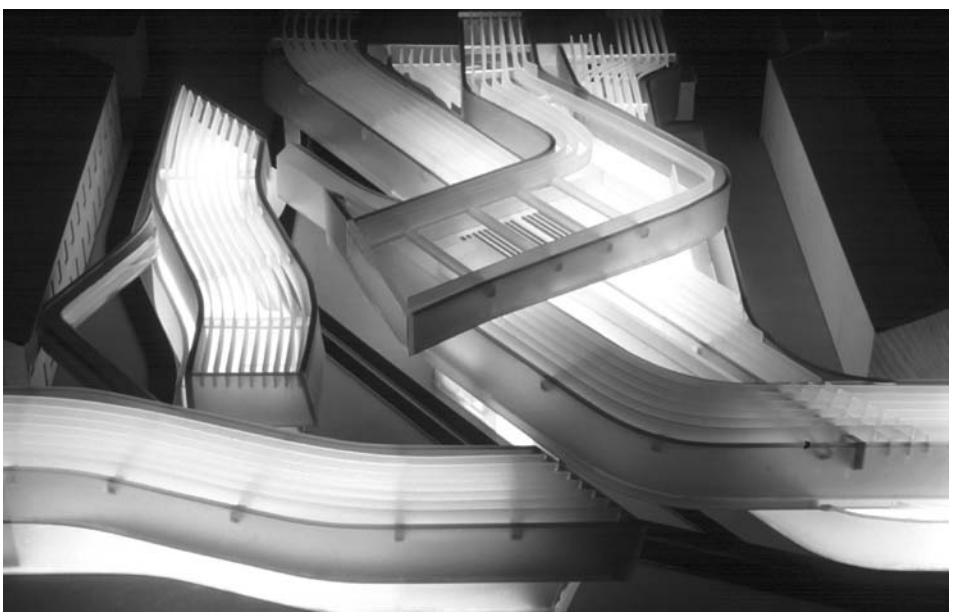
Three closely related conceptual art movements have much relevance to today's crisis in the status of the architectural image: Arte Povera, process art, and art-and-technology. Conceptual artists who participated in the discourse of the late 1960s concluded that what was most intrinsic to art was not its object-status, but rather first, the inherent cognitive concept, and second, the open-ended explorative process of expressing the concept.[3] These notions later filtered into architecture via architects and designers whose social networks extended into conceptual and process art circles. Some of these architects—Rem Koolhaas and Zaha Hadid at the Architectural Association, and Daniel Libeskind as director of Cranbrook Academy—introduced new design methods into studio pedagogy, which were later reflected in their built works.

In addition, conceptual artists also saw art as expressive of a larger social and biological system. As they began their investigations, conceptual artists determined that there were no clear boundaries between the artist, the art expression, and the audience. Such theorizing was not unique to art but manifested throughout science, music, performance, and linguistics. By transposing the art debate of the 1960s and 1970s onto architecture, Swiss architects Herzog & de Meuron, among others, allowed new possibilities to emerge in their designs: architectural expression could be said to operate on multiple registers, only one of which is material; it is defined by a process, and is part of a larger cultural and biological system.[4]



3.3
Zaha Hadid Architects:
Rosenthal Center for
Contemporary Art,
Cincinnati (2003)
A painting by Hadid
describes urban flows.

3.4
Zaha Hadid Architects:
The Contemporary Art and
Architecture Center for
Rome (1999–present)
A digital rendering of the
museum complex "irrigat-
ing" a large urban field
with linear display surfaces.



Essentialism or anti-essentialism

Early twentieth-century codes of normalcy or appropriateness in art have been said to originate with the art critic and historian Joshua Reynolds. In his *Discourses on Art* (1771), he attempted to formalize art's universal principles of art's pan-historical greatness.[5] Reynolds also initiated the concept that paintings were experienced "all at once" because they occupied a defined space and were perceived in one moment of time. The other notions received from Reynolds were first, certain media do certain things in certain ways (medium specificity); second, art genres should not exceed their boundaries, for example in the transference of one medium into another; and, finally, the importation of one medium into another violates conventions.[6] One can contextualize these principles as expressions representing the permanence or stability of an existing aristocratic hegemony. Additionally, they supported the view that architectural expressions, whether images or buildings, exist in fixed, static, timeless modes.

Reynold's treatise was a refinement on the dramatist and art critic, Gotthold Ephraim Lessing's earlier essay, *Laokoon* (1766). Lessing contrasted painting's singular moment of perception with the temporality of poetry. His distinction was that poetry was best represented consecutively, that is to say, sequentially, because it was experienced over time.[7] Both Reynolds and Lessing agreed on promoting rigid or inviolable media boundaries and were unable to entertain the possibility that media might be combined.

Although Reynolds and Lessing were certainly influential, the leading figure of twentieth-century arts criticism, Clement Greenberg, was ultimately responsible for many of our accepted conventions about aesthetics. "Purity in art consists in the acceptance of the limitations of the medium of the specific art … an art which is nothing else except sensuous."[8] His "Towards a Newer Laokoon", written in 1940, evolved from arguments by Reynolds and Kant to justify criticism of art. His two main ideas were that art (as he defined it) is a nonconceptual, subjective, universal, and irreducible pleasure, and that aesthetic judgment is disinterested and detached.

Speaking as an unrestrained positivist, Greenberg was responsible for perpetuating the limiting concept of medium specificity. His writings were an appeal for an explicit and rational structuralism of the arts. In his view, the medium of art, its materiality, was paramount, because it was the ultimate grounding for the work of art. Even more importantly, only abstract art was considered a pure expression of the medium, because Greenberg reductively concluded that flatness and opticality were the only two irreducible aesthetic experiences in painting. In addition, abstract art, to maintain its purity, also required absolute integrity, which is to say no mixing of other media.[9]

While Greenberg directed his criticism to paintings and sculpture, his theories were not unfamiliar to architecture. If we reexamine architecture's genealogy, we see that the discipline had historically inherited certain notions from Classicism related to integrity and medium specificity. Classicism (which, broadly speaking, includes Greek, Hellenistic, Roman, seventeenth-, eighteenth- and some nineteenth-century architecture)[10] established a prescriptive system: a system that was composed of rules determining the acceptability of a design's formal or functional aspects on the basis of nonviolation of certain constraints. (Formal architectural systems similar to Classicism, for example, typologies and most building regulations, are likewise prescriptive systems.) As ancient Greek aesthetics attempted to purify the form, their constraints were maintained throughout subsequent architectural treatises, from Andrea Palladio to Marc-Antoine Laugier, and even Robert Venturi's postmodernism; all consistently referred back to Classicism as their true origins. Thus occurred a repeated resurgence of classical normative coding after the Middle Ages, from the Renaissance through the eighteenth century, and continuing with the various revival styles of the nineteenth century. Architectural pedagogy as well as practice consisted of a historical referencing, a recombination of preexisting elements, and an uncritical acceptance of tradition.[11]

When World War I resulted in a social and cultural break with aristocratic aesthetic privilege, the efforts of the avant-garde, primarily the de Stijl movement and other early Modernists, provided the means for early twentieth-century architects to break with history. In an attempt at self-criticism best represented by Le Corbusier and the International Style, modern architects established their own version of formal purification. However, while it is commonly acknowledged that Le Corbusier's modernist version of functionality, purity, and the machine aesthetic effectively replaced the Vitruvian coding of *utilitas, firmitas, venusta* (useful economy, structural integrity, and aesthetic pleasure), even Le Corbusier did not actually make a clear historical break, but studied classical proportions to justify the forms of racecars and his own system of regulating lines.[12]

3.5
Bruce Nauman: *Live/Taped Video Corridor* (1969–1970) Wallboard, video camera, videotape player and two video monitors; dimensions vary with installation. Gordon Madda Clarke's *Splitting: Four Corners* appears on the left.

By mid-century, with few exceptions, the architectural discourse lagged behind the internal art debate as a result of the post-World War II expansion. Much of it was due to the fact that the architectural discipline had to contend with a severe housing shortage and new construction methods. While isolated moments of critique and experimentation existed—such as the Situationists or Canbera—the majority of architects were preoccupied with the demands of a rapidly expanding economy. As a result, most architects were otherwise engaged with topics related to functionality and standardization,[13] and were left with little time to reflect on the implications of Keisler's "Endless House," or the "static objectness" of painting through the new medium of film.[14]

Conceptual art and architecture

It was 1969 when philosopher and social critic Michel Foucault, in *The Archaeology of Knowledge*, ventured that the crisis of classical thought was a crisis produced by a loss of ground. Within the field of art, this loss was accompanied by the loss of an art-product produced on the basis of a desire to represent. It has been suggested that this loss was actually initiated much earlier in the century by artists' adoption of a new technology, photography, which destabilized traditional art practices such as portrait and landscape painting. The Surrealist André Breton believed that it was photography's indexical character that compelled a reexamination of art's ontological origins and purpose as well as the grounding of the discipline itself.

Breton's argument, as structured, was that artists in the classical tradition *represented* a preexisting condition, whether or not through the aid of Cartesian perspective, the camera obscura, or other optical devices. Avant-garde artists of the early 1900s, on the other hand, were making attempts to *present* an original concept or idea previously unknown. Influenced by Freud's psychological research, Cubism, Surrealism, and Dadaism expressed previously unseen subjective worlds. They "sought to explore the unconscious as a site of meaning and to challenge rationalist distinctions between self and other, inside and outside, conscious and unconscious."[15] In a sense this was, in fact, a liberation of art from the constraints of representation, thereby freeing it up to do what only art can expressly do.

However, the end of the Classical age, which Nietzsche announced as an end without return, was in actuality the exhaustion of the early rationalist modernist project. By the 1960s, moreover, art was responding to an even more complex set of factors. In addition to the critique of rationalism, it was also opening up to interdisciplinary or cross-cultural ventures. In the wider social milieu—student riots, new divorce laws, a mixing of high and

low culture, the influence of advertising and mass media—all these factors marked the disappearance of any kind of absolute referent that might in some way frame a system of absolute knowledge or a unified version of reality.[16]

While there were many avant-garde movements in the late 1960s and 1970s that attempted to articulate this disappearance of ground, conceptual art had particular bearing upon the architectural image:[17] the broader rubric of conceptual art applies to "work in which the idea is paramount and/or the material form is secondary, lightweight, ephemeral, cheap, unpretentious and/or dematerialized".[18] These art movements were directly related to the transformation of the architectural image because of two major contemporaneous trends: first, new theories of representation, and second, new technologically derived mediums. Both of these resulted in an unprecedented dematerialization of the art object.

This ontological crisis of representation is crucial to an understanding of one of the resistances that architecture has had toward new forms of media expression. Traditionally, architects represented an idea in a drawing, and then the drawing was represented in a building. Although the drawing had documentary status, it needed to be further translated into another medium, that is to say, into material form. If in actuality architects only construct ideas and the design evolves dynamically as a process, then all expressions, in whatever media, are a record of the process. Architectural expressions then participate in a larger design continuum with conceptual or cognitive activity at one pole and materiality at the other, and with many variants or media in between. Rigid distinctions between media are not only unnecessary but patently misleading.

In one of their few areas of agreement with Greenberg, conceptual artists also apprehended the increasing colonization of art by consumer capitalism. In "Towards a Newer Laokoon," Greenberg's critique of capitalism was grounded in a fear of mass culture and loss of an essentialist aesthetic.[19] By the late 1950s and early 1960s Pop Art needed to be defeated in that it reified capitalism, and Greenberg was convinced that only abstract art, because of its pure medium specificity, could carry this burden successfully. It was ironic, however, that he was unable to recognize how artists themselves had been converted into a form of cultural capital as a result of the economic processes of art production and consumption.[20.]

While Abstract Expressionists and Minimalists were still producing discrete form-objects distributed through a traditional gallery system, conceptual artists saw a decreasing range of expression if they adhered to the preordained medium-specificity protocol. Hence,

3.6
Andy Warhol: *Campbell's Soup Can: Tomato*

their efforts were directed toward a deterritorialization of art from its commercial context in such a way that new possibilities could emerge. In this substantial respect, conceptual art differed from the avant-garde. As art historian Edward Shanken explains, "Resisting the arch formalism that had become institutionalized by the 1960s, conceptual art … sought to analyze the ideas underlying the creation and reception of art, rather than to elaborate another stylistic convention in the historical succession of modernist avant-garde movements."[21]

The disseminated anti-rationalist writings of John Dewey, as well as the widely discussed writings of Roland Barthes and Umberto Eco, were among key sources validating new approaches to the art process. They endorsed exploration, complexity and diversity. This open and fluid approach, while not denying history, allowed it to be renegotiated.[22]

The redefinition of creative processes was also extended to unorthodox materials. In Turin, Italy, Arte Povera challenged the assumption that only marble or bronze were suitable materials for artwork. Trash or refuse, industrial materials, even people, as well as immaterial substances such as moisture, sound, or energy, any of these could be art. Concurrently, art-and-technology questioned what type of media is inherent to artistic expression: only normative inert media? Instead, conceptual artists believed that art expressions could be gestured, spoken, written, acted, filmed, industrially produced, or conceptualized. The work of art might exist as a momentary, time-based action, such as performance, as in the example of Arte Povera artist Michelangelo Pistoletto's *Ball of Newspapers (Minus Objects)* (1966–1968). As event and performance, the immense papier mâché ball was rolled through the streets of Turin and filmed. Later, the ball, as sculpture, was enclosed in a metal cage and retitled *Mappamondo (Globe)*; this version appeared in an exhibition in Amalfi. Pistoletto was ultimately questioning the nature of event: is it documentary (newspapers) or actuality (performance)?[23]

But foremost, and above all, was the investigative and participatory process. For example, Emilio Prini, who produced some of the most dematerialized work associated with Arte Povera, was absorbed with experiments with space and time, and sought to reconnect aesthetic experience with a durational experience of lived time. This echoed explorations on the notion of duration by Henri Bergson. In *L'USA usa* (The USA Uses, 1969), a tape recorder continuously recorded its own mechanisms until it broke down; in *Asta Curbata* (Bent Pole, 1967), the viewer's attention was directed away from the idea of the work of art to an awareness of the basic dimensions of space, and thus to experience itself.[24]

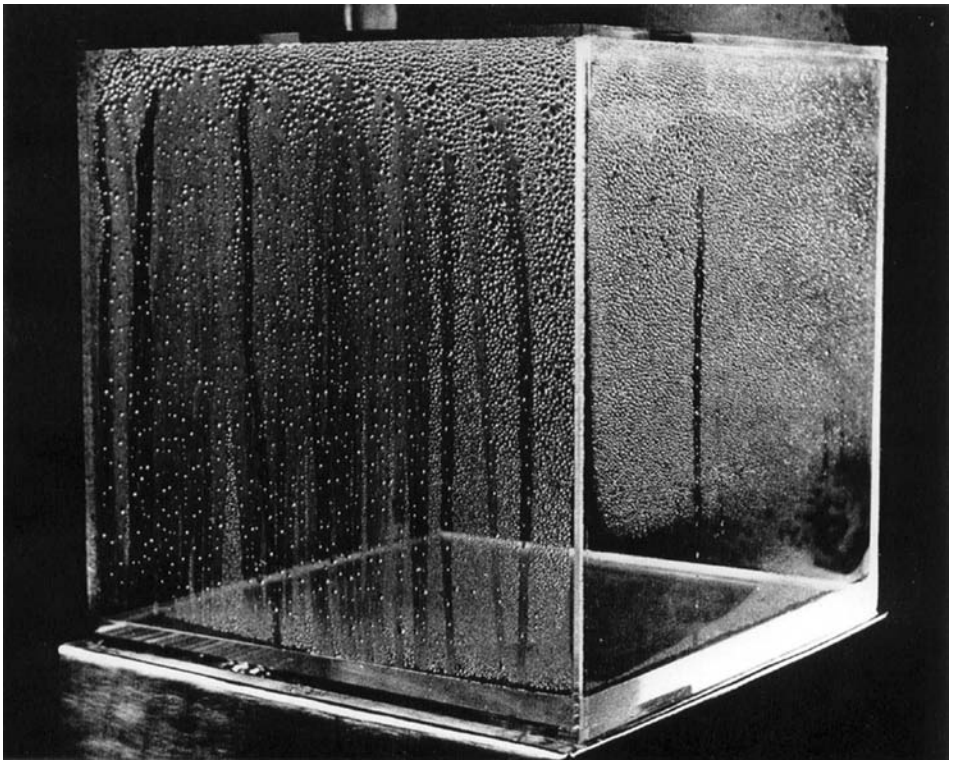
3.7
Herzog & de Meuron:
Ricola-Euope SA
Production and storage
building, Mulhouse-
Brunstatt, France (1993)
Reflections off wet surfaces
dematerialize the structure.

These installations did not remain as singular or isolated moments within the art world, but formed a trajectory into contemporary architecture. Jacques Herzog and Pierre de Meuron, Peter Zumthor, Elizabeth Diller, and Richard Scofidio have all espoused claims to actively participating in and embracing the philosophies of conceptual art. Pritzker Award winners Herzog and de Meuron frequently collaborated with artists as part of their design method. The architects explained that each project begins with a particular form of nondirected questioning; the inclusion of an artist reflects their refusal not to know in advance what a future building *ought* to look like. Swiss artist Remy Zaugg concurs: "If we know what art or architecture are, we, you and I, merely produce illustrations of what we already know about architecture or art."[25] In another collaborative project with a biologist, Herzog designed a garden structure, the EDEN Pavilion, which reacted to the weathering process of lichen by transforming the concrete roof structure into a generative canopy. Instead of memorializing a static moment in time, the architectural expression encompassed temporality, interacting with the environment whether sun, fog, or rain.

When closely analyzing conceptual art, we find that many of the rigid disciplinary boundaries and categorizations were initiated through critics and the academies and not by the artists themselves, most of whom resisted all attempts at classification. Therefore, it may be confusing that, concurrently with Arte Povera, American artists Bruce Nauman, Walter de Maria, and Michael Heizer were linked with what was termed process art. This differed from conceptual art in that an artist would set a process in motion and await unpredictable results, exemplifying a radical shift from artist as primogenitor to artist as one who sets up an autonomous and random process. In Hans Haacke's Plexiglas cubes, or "weather boxes," water condensed and evaporated according to the changing levels of light and temperature in the gallery. "A sculpture that physically reacts to its environment and/or affects its surroundings is no longer to be regarded as an object," explained Haacke.

> The range of outside factors influencing it, as well as its own radius of action, reach beyond the space it materially occupies. It thus merges with the environment in a relationship that is better understood as a system of interdependent processes. These processes—transfers of energy, matter or information—evolve without the viewer's empathy … A system is not imagined; it is real.[26]

Systems thinking, as well as cybernetics, were at the same time making their way into other disciplines, including architectural design theory. Within the architectural discipline, self-criticism occurred primarily through Horst Rittel and other Second-Generation theorists during the 1970s, who critiqued scientific rationalism's prescriptive methods and



3.8
Hans Haacke:
Condensation Cube (1963)
30 x 30 x 30 cm
Clear acrylic, water, light, air currents, temperature, climate in exhibition situation. Haacke was already concerned with systems and processes; here he demonstrates the dependency of a relatively closed system on the environment in which it is situated. Changes in temperature and humidity lead to condensation and evaporation within the cube.

forged interdisciplinary design research.[27] Advances in technology, psychology, computer sciences, and especially "autonomous design" were impinging on academic disciplines, creating a need for them to come to terms with the very same issues regarding media and methodology that we face again today. The art critic Jack Burnham

> pushed the exploration of the relationship between art and technology to an unprecedented point. In 1970, he curated the exhibition *Software, Information Technologies: Its New Meaning for Art* … the show drew parallels between the ephemeral programs and protocols of computer software and the increasingly "dematerialized" forms of experimental art, which the critic interpreted, metaphorically, as functioning like information processing systems.[28]

Most conceptual artists also incorporated an interest in perceptual psychology and the role of the viewer, in addition to the processes of making. Foremost was the primacy given to immediacy of the experience, traditionally associated with architectural affects. This notion was reflected in the increased scale of their projects, often exceeding traditional gallery or museum space, and venturing into architectural modes of expression. In one example by Joseph Beuys, the negative space of the exhibition hall is defined by stacks of felt and the walls. In another, Beuys removed the exterior wall of a gallery that directly faced an alleyway, and thereby engaged pedestrians as part of the installation. In conceptual moves borrowed heavily from the Situationists, materialized actions of passersby and coincidental meetings in time contributed to the work of art. These efforts suggest an element of interactivity and a merging of art, technology, and architecture. Conceptual art was dedicated to the possibility of making art outside of conventional media, outside normalcy.

By dismantling the inherited frame around defined art, that is to say the frame of medium specificity, artists opened up the territory of art to include the immaterial conceptual realm as a way to renegotiate the art experience. The ultimate infiltration of these three art movements—Arte Povera, process art and art-and-technology—into architectural modes of thinking and production was perversely caused by an extended economic recession during the late 1970s and 1980s. We find the stance taken up by architects who were familiar with both process art and performance: in the United States, Diller Scofidio + Renfro utilized this approach with their Times Square installation, *Soft Sell* (1993), and their performance of Duchamp's *Delay in Glass* (1986). At that time there was little new work and even less construction, so newly graduated, ambitious, yet unemployed architects began to transgress art's historical territory in search of new forms of architectural

expression.[29]

Perspectives

The furthest trajectory of this line of questioning led to the notion that the intrinsic experience of cultural production might be nonmaterial. It was further elaborated in two influential writings: Robert Smithson's "A Tour of the Monuments of Passaic New Jersey," and "Talking with Tony Smith," which included Smith's night ride on the unfinished New Jersey Turnpike.[30] Both essays radically altered preconceived attitudes about the art experience:

> At first I didn't know what it was, but its effect was to liberate me from the many views I had about art. It seemed there was a reality there that had not any expression in art. The experience on the road was something mapped out but not socially recognized. I thought to myself, it ought to be clear that's the end of art. Most painting looks pretty pictorial after that. There is no way to frame it, you just have to experience it. [31]

Smith's view radically differs from previous social codifications of the art object, in that he was attempting to define the art expression as nonmaterial, that is to say, as an experience. A similar rupture was repeated by conceptual artists who explored "networks of signification" by deploying language through the information arts. Their efforts led to a larger critique of traditional art norms by analyzing the operative relations within semiotic systems.[32] Contingencies of meaning and material converged in the first digital art installations as diverse as Nam June Paik's *Zen for TV*, Sonya Rapoport's *Goethe's Urpflanze* (which later evolved into *Shared Dynamics*), and some of the early art-and-technology interactive digitally-based art works.

These approaches could then be similarly applied to architectural expression, making it possible to frame architectural production in a more conceptual way. Given that materiality was replaced exclusively by an ephemeral experience, contextuality becomes foregrounded and instrumental in the perception of the work of architecture. Historically, classical/modern architecture viewed the singular built object as inseparable from the architectural experience. However, upon reexamination, this is always revealed to be an assumption. The definition of an architectural experience is in fact embedded within a larger social and cultural system.

One aim of critical theory has been to remove surface layers of materiality and expose the invisible forces operating on form, which describe an intricate network of social and

3.9
Joseph Beuys: *Fonds VII/2*
(1985)
Eight piles of felt, plaques,
wires, and objects.

3.10
Nam June Paik: *Zen for TV*
(1963)

economic relationships. This leads one to suggest that the intrinsic architectural experience might not be materially grounded—that it might actually be a set of relations or even

a special kind of attention existing outside normative boundaries. This notion is not unique, but was advanced earlier by Conceptualists who indicated that the most exciting "art" might still be discovered in social energies not yet designated as art, or by John Cage in regard to musical composition and Dr. Eleanor Rosch in her psychology research.[33] However, its acceptance can only be predicated on a reexamination of existing architectural design theories and a proposition of a new ground rather than a deconstruction *per se*.

It also seems evident that instead of yet another reactionary avant-garde movement, the various threads of conceptual art were actually an attempt to deterritorialize art, to abstract it from a historically bound context in such a way that new interpretive connections could be formed. This process of deterritorializing further recoded the interpretive matrix of the original context as part of a socially reflexive process. First, while Arte Povera may not have specified exactly what art *is*, it certainly reinscribed the boundaries of art production to encompass the conceptual or nonmaterial. Second, Process Art revealed the narrative process of its own making or construction, so that whatever form the art object might take, it also occupied a transition in time. Third, art-and-technology, using less material modes of expression, found a way to define art as a set of social relations, even if technologically supported.

Emergent from the 1960s internal art debate was then a broader perceptual shift, which eventually found its way into architectural pedagogy and practice. By the mid-1990s new theories of representation and technologically derived media supported a more diverse means of expression for architects, including installations, animations, videos, and websites, once again generated during a building recession. The gradual infiltration of these three art movements—Arte Povera, process art and art-and-technology—as part of the larger conceptual art movement, into architectural modes of thinking and production, indirectly contributed to a transversal of media boundaries to include digital forms of expressions, and ultimately to an unprecedented dematerialization of the architectural form-object.

3.11
Art is continually being renegotiated: the Tissue Culture & Art (Oran Catts & Ionat Zurr) in collaboration with Stelarc
Above: *Extra Ear* small in hand (2003)
Below: *Extra Ear* close-up (2003)
Semi-living sculptures of biodegradable polymer and human chondrocytes cells.


A LOT OF PROFESSIONALS
ARE CRACKPOTS

3.12
Diller Scofidio + Renfro:
Soft Sell Times Square
(1993)


MOSCONE
WEST
24th ST

4
Mapping absence

Architectural contingencies

4.1
Diller Scofidio + Renfro: *Facsimile,* San Francisco, CA (2003)
The city becomes the viewing context; the viewer and the image occupy the same space in this media installation.

A dictionary begins when it no longer gives the meaning of words, but their tasks.
Georges Bataille[1]

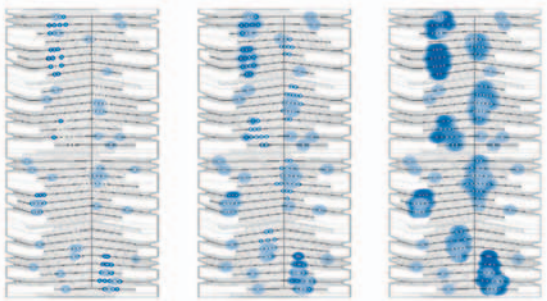
New forms of architectural expression, sometimes called transmedia or multimedia, that combine digital technology and whose constructions typically cross disciplinary boundaries—such as interactive art installations or architectural interventions—are often linked to Internet sites. A number of architectural firms, large as well as small, have a significant body of work in this area: Diller Scofidio + Renfro, Zaha Hadid, and servo, to call attention to only a few. If interactive art installations are to be considered with respect to architectural interventions, that is to say as a contingent object of architecture, then it is advantageous to explore the ambiguous nature of digital materiality first and foremost, and how it is operative within notions of deterritorialized space.

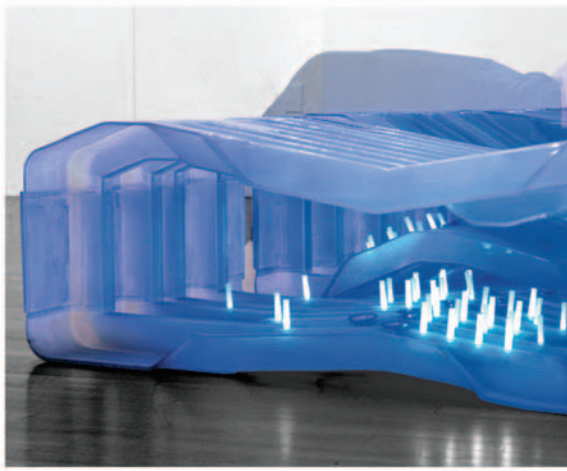
Technological advances that result in new modes of perception have overturned representational models in the past. With photography, the fine arts began a series of self-investigations early in the twentieth century. Duchamp's *The Bride Stripped Bare by Her Bachelors, Even (The Large Glass)* (1915–1923), and *Network of Stoppages*, were two frequently cited examples in terms of doubling, ephemerality, and transparency. Duchamp, along with other artists of the time, was keenly aware of advances in the sciences, particularly quantum theory in physics, the relativity of time, and observer-relative viewpoints. By mid-century, the mathematician Norbert Weiner at Massachusetts Institute of Technology was also developing his widely published research in systems theory, *Cybernetics or Control and Communication in the Animal and the Machine* (1948), related to complex adaptive systems, artificial intelligence, and network theory. All these developments resulted in profound perceptual, epistemological, and ontological shifts within their respective fields.

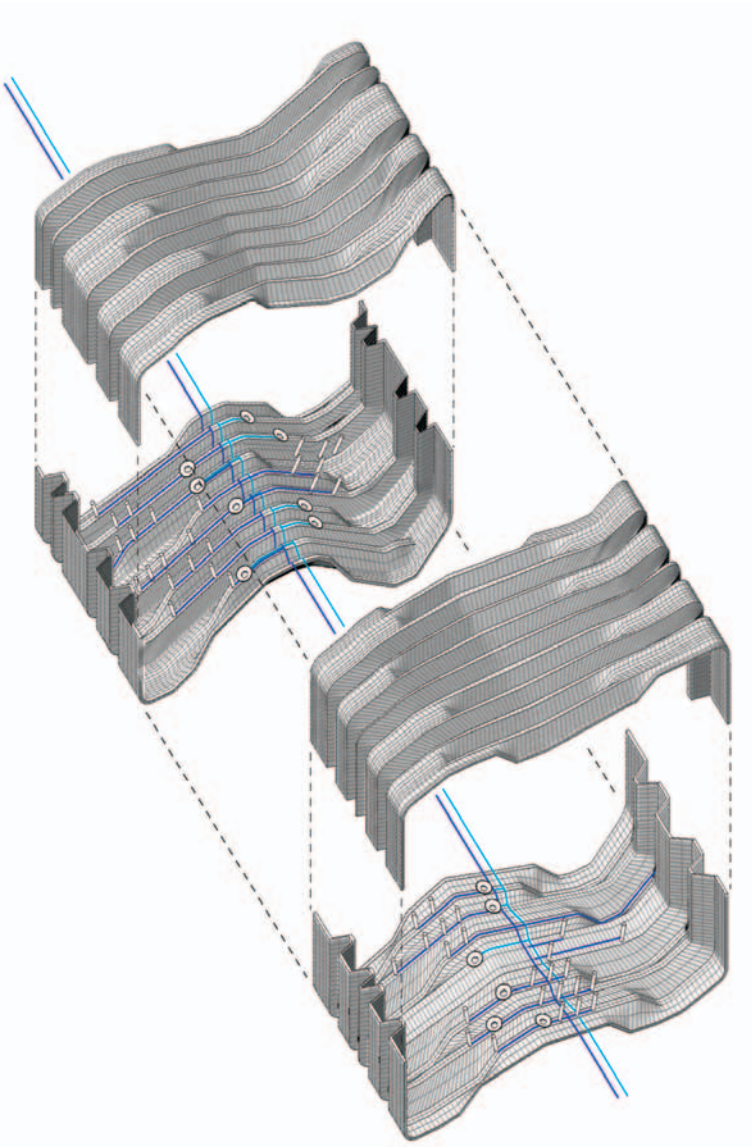
4.2
Thermocline reconceptualizes the infrastructure of a conventional furniture unit by transforming the tactile interface of surface-to-body into an interactive multisensory micro-environment. The vacuum-formed corrugated acrylic shells allow multiple ergonomic positions while simultaneously providing synesthetic effects of sight, sound, and touch. An array of sound sensors distributed throughout the gallery space collect residual conversation as a byproduct of the exhibition environment. This sonic information is then distributed to a central computer and processed by software. The result is a dynamic feedback loop between Thermocline and the space of the gallery itself, each informing the other as material and immaterial information is passed back and forth.

Originally commissioned by the Wexner Center for the Arts for the exhibition Mood River in 2002, and Non-Standard Architectures at the Centre Pompidou in 2003.

Images clockwise from upper left: body pressure points were digitally mapped; the data was used to fabricate the mold; components with interactive technologies; the finished Thermocline in use.



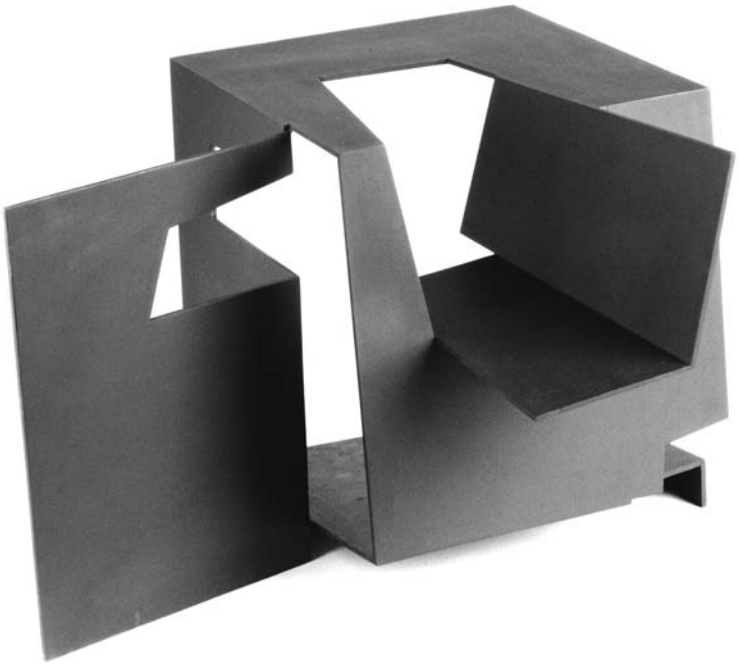




Architecture, however, was with few exceptions fairly resistant to the challenge of its disciplinary orthodoxies. This resistance could be said to have originated in systems of knowledge that sited architecture first and foremost within the physical material realm, both in pedagogy and in praxis. Nevertheless, a few iconoclastic mid-century architects, most notably Buckminster Fuller, saw synergy as a basic principle of all interactive, interrelated systems, as demonstrated in his designs for the *Dymaxion House* (1967), the geodesic dome at the Montreal World's Fair, and his futuristic megastructures.[2] Britain's Archigram Architects (1961–1974), Peter Cook *et al*., proposed imaginative structures for nontraditional uses, in particular *Living City* (1963), in addition to Cedric Price's innovative *London Zoo Avery* (1960–1963). Price's unbuilt *Fun Palace* (1960), and *Inter-Action Centre* (1971) described unprecedented flexible notions of public space, which included user-generated programming and interaction. Price envisaged architects as agents of positive change within a world of continual alternation. Designers were visionaries who could offer new possibilities, conceptual as well as built, for society as a whole. To Price, architecture was not only about physical buildings *per se*, but also about the "thinking the unimaginable."[3]

Concurrently, a line of philosophical questioning that was later adopted by architectural theorists developed into alternative ways of looking at architectural design. Beginning in the late 1960s and early 1970s, interpretive modes borrowed from other disciplines—Marxian, phenomenological, psychoanalytic, semiology, among others—gave theorists new texts for rethinking architecture in relation to other fields within the academy. Fostered by critical thinking, initially by Manfredo Tafuri and Mario Gandelsonas, and later borrowing from structuralism and poststructuralism with John Hejduk, and Peter Eisenman, they outlined a philosophical framework for architecture that was linked to cultural production by proposing that theoretical knowledge not only underlies architectural methods and expression, but also forms part of a larger social, cultural and intellectual system.

4.3
Jorge Orteiza: *Homanage à Mallarme* (1958)



A number of theoretical positions that emerged about this time can help in an understanding of the complex relationship of architecture to interactive art. The first was the notion of *informe* or formless, reclaimed from Georges Bataille by art critics Yves-Alain Bois and Rosalind Krauss. While there have been numerous discursive texts historically associated with absence or negation, most often related to Nietzsche, what Bataille was suggesting was the possibility of a formless that could also be productive. Bataille employed it in opposition to André Breton's historical materialism by instead proposing a more base materialism or one previous, permeable, and provisional, the *formless*.[4] Bataille's definitions function as a set of operations, or "instructions for use." However, Bois and Krauss appropriated Bataille's *formless* as a means to question art criticism's traditional binary of form and content. As a third possibility, *formless* disrupts the unity and stability of visual space[5] by destabilizing the organizing principle of form.

In some respects, Bois and Krauss's project is a recursive iteration of an earlier essay, "The Photographic Conditions of Surrealism" (1981), which acknowledges *Inscription of an Origin* (1976) by the French philosopher Jacques Derrida. Derrida's ideas merit reviewing, not only because his essays attempt to articulate a "tenuous relationship between a certain kind of thinking and a certain kind of space"[6] but also because his brief collaboration with Peter Eisenman was instrumental in linking the literary theory of deconstruction to architecture. In *Peter Eisenman: Recent Projects* (1989), conditions for an architecture, an object, that could be said to "provoke an uncertainty" were outlined.

What is of particular interest here is Derrida's operation of the supplement, which restores the necessary dependence of absence and presence as it relates to material expression. Derrida's model of the "space between" is highly useful, in that it allows for an interpretation of formless and, more importantly, outlines a method of examining the contingent object of architecture, the image, through its constitutive elements, in this case, programming code.

Derrida's concept of spacing was used to justify the incompleteness of things. Within each constructed binary, A is the opposite of B; however, A needs B to exist—for example, figure needs ground, outside needs inside, absence needs presence. Therefore, A always bears a trace of B, because they depend on each other for definition. Yet according to Derrida's concept of the supplement, A is also unlike itself because it always bears the trace of B. The combining of unlike things is what creates the space of *différance* or multiple readings,[7] and as such it could be said to exhibit transmedia characteristics.

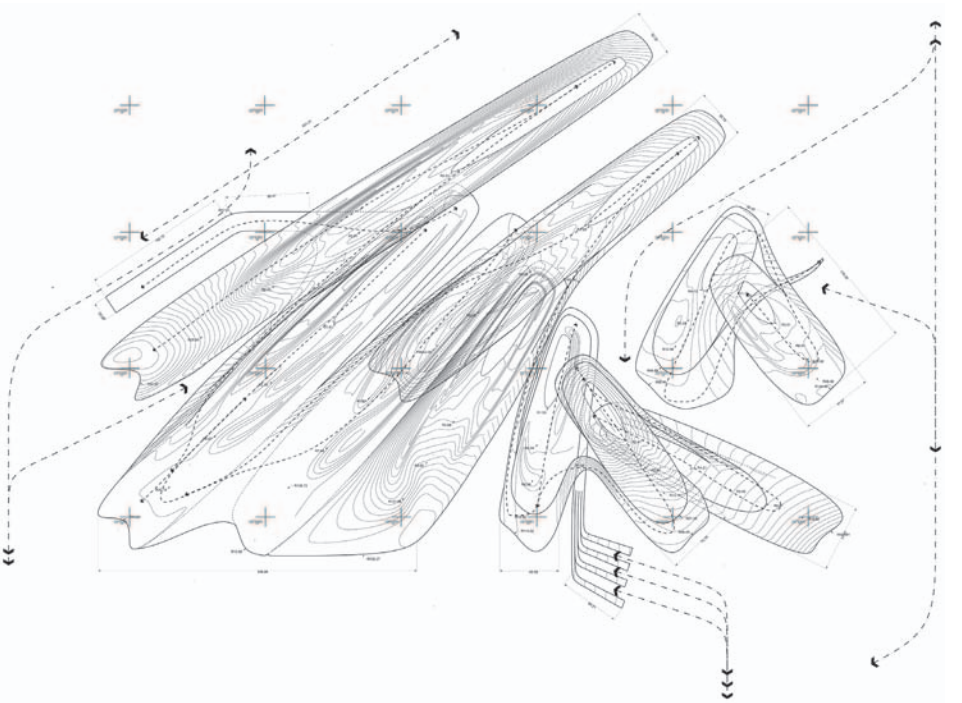
4.4
Diller Scofidio + Renfro: *Facsimile,* San Francisco, CA (2003)
Detail of exterior moving screen. A 16 x 27 ft LED video monitor faces the street, and scans the transparent glass façade for interior activities. These images are transmitted live and interspersed with fictional videos, calling into question, fiction and reality.

4.5 (left)
Diller Scofidio + Renfro *Facsimile,* San Francisco, CA (2003)
The architects created over 20 hours of video programming for the installation.

4.6 (right)
Infinity Edge: Park for the 21st century (2004)
Ramiro Diazgranados and Georgina Hulich's proposal combines a field condition with self-similarity.

This implies a questioning of the gap between thought and speech, speech and text, representation and reality. Since absence cannot be stated, one interpretation of spacing is that the demand of reading is to occupy the space between what is there (text) and what is absent (concept). Spacing is always outside the figure of the text. This absence is necessary but not described. However, the ground, when recognized, has presence, yet it is contingent, existing at the margins of communication.

There are two important points here related to the digital architectural image. First, the digital image is constructed, not drawn, through a programming language (code); the code is at once present, and also absent, because it is no longer visible. Second, the digital image has no one associative meaning; instead, its meaning is always relative, always resisting any essentializing efforts. Perhaps it could be possible for an architecture to pick up that condition, that outsidedness, within the mode of presencing. If so, then the aesthetic discipline would have to be open to redefinition—a redefinition necessitated by the adoption of digital methods, since architecture's once-tacit materiality is now open to question.



While the concept of spacing functions as an operational medium between conceptual and expressed architecture, it is also important to understand that European intellectual history has tended to structure its ideologies and paradigms into linear sequential systems composed of binary opposites. Since Plato, this model has worked its way into many seemingly disparate disciplines, from logic (Descartes) to linguistics (Chomsky's theories) to psychology (categories of normality/abnormality). Dichotomous modes of thought have penetrated and blocked the potentiality of a social space to present itself as a fully deterritorialized milieu.

The beginnings of this discursive shift occurred outside of architecture. Roy Ascott's *Behaviorables and Futurables* (1967) and Jack Burnham's *Systems Aesthetics* (1969) traced similar forces at work with new forms of digital media. Poststructuralism's response, via modern art criticism and philosophy, attempted to transfer the focus from object-based dualism to field dynamics, that is to say, from stasis to relations. Again, Rosalind Krauss perceptively described axiomatic inconsistencies in her essay "Sculpture in the Expanded Field" (1979).[8] The recognition of a formless structural potential to inform social space was later outlined in Stan Allen's theoretical research on field dynamics. In a 1998 essay, the architect described "a field condition" as

> any formal or spatial matrix capable of unifying diverse elements while respecting the identity of each. Field configurations are loosely bound aggregates characterized by porosity and local interconnectivity. Overall shape and extent are highly fluid and less important than the internal relationships of parts, which determine the behavior of the field. Field conditions are bottom-up phenomena, defined not by overarching geometrical schemas but by intricate local connections.[9]

And echoing Derrida, "Form matters, but not so much the forms of things as the forms *between* things."[10]

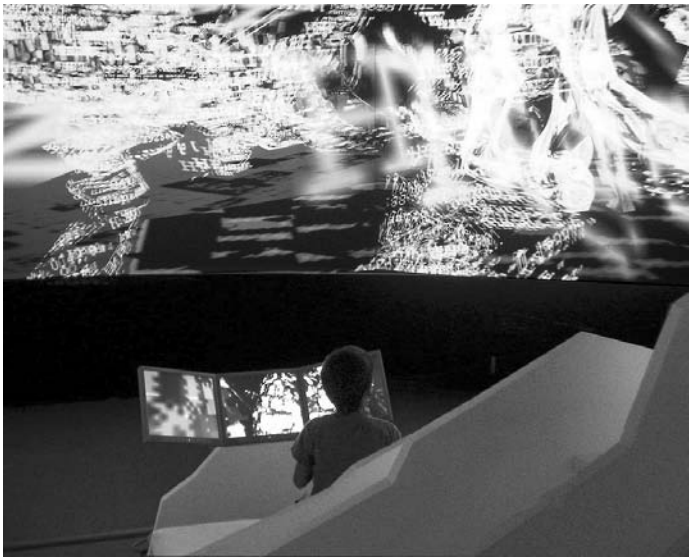
Furthermore, if interactive art installations displace stasis for relations, then the concept of multiplicity, derived from a Bergsonian idea of image, suggests that "we [should] see things as functions of actions in and reactions to a milieu."[11] In this sense, Deleuze has recontextualized the concept of spacing and the supplement from Derrida. But instead of using written text's inherently 2-D linear structure, the in-betweeness has spatialized into an unstable and porous 3-D field of relations through the introduction of a rhizomatic system.

The notion of a variable spatialized field of relations occurs as part of a larger paradigm shift, one that includes emergence, point-to-point organization, and complex networks. The basis of network theory can be understood as a fundamental oscillation from substance to systems. Returning to Weiner's cybernetics, in the 1970s the designer Gyorgy Kepes proposed, "What scientists considered before as substance shaped into forms, and consequently understood as tangible objects, is now recognized as energies and their dynamic organization."[12] A network is very different not only from a linear sequential model, but also from a conventional matrix or grid, primarily because a network's structural organization is described by energy or information. These structures are neither technic nor mechanic, but instead can be understood as activities in terms of variable conditions and operations. Superficially analogous to a three-dimensional neural network, this theoretical model deterritorializes specific aspects of other concepts onto itself in a way that opens up possibilities of further positive conceptual development, as a meshwork of connections across which things flow and disperse. A network, like architecture, is spatialized, yet unlike architecture, it is dynamic and flexible. It is both "there" and not there, existing as a simulated moment in time incapable of stasis and therefore incapable of any full or self-evident representation. Thus having no center, no solid structure, the network is nonrepresentational.

It is, in fact, anti-representational, recalling Bataille's *informe*, and only imaginable through a concept of multiplicity that calls into question any essential wholeness of the subject. From this perspective, it could be described as a mapping of the in-between, a mapping of the absent, which through the action of the supplement always bears the trace of presence.

As an organizational model, the very lack of a stable ground, the unstructured space between absence and presence, suggests a fluidity or porosity. Thus, the gap highlights the space in between, what is invisible (the code) and what is visible (the event space), and in this respect all that remains is the variable organizational relationships existent within slices of time.

This poses an ambiguous question, which is linked not only to medium specificity but also to the ontological consistency of the architectural product. If architects have not produced buildings since the Renaissance, as some have argued,[13] one could speculate that what architects actually produce is a process. Even their conventional product, a set of construction documents, is in reality a set of instructions.[14] In actuality, the only product that an architect ever produces is a set of instructions, a description of an ordering system that is itself scripted.



The notion of creating a set of instructions continues the same line of thinking that conceptual artists, such as Hans Haacke, and art-and-technology (Chapter 3) were exploring during the late 1960s. If an artist sets up a system or set of instructions, then the process is all there is. If the architect is designing a process, albeit a set of relations (whether social or organizational), the process itself becomes a continuum of expression generated by conceptual thought. Coding defines operations, which then affect their contextual environment. Inasmuch as it is possible to define architectural expressions in terms of performatives, with verbs—that is to say, *what architecture does*—then whatever pressures shape a network of social relations could be said to constitute a form of architecture.

As described earlier in the book, artists and architects have shared communication tools and expressive media throughout history. At present, artists as well as architects create programming scripts to direct formal processes. Code is both an executing program and a formative process, in that it supports activities and events with the ability to generate some type of affect or experience. At the same time, new media's reformulation of architectural design process collapses normative boundaries because the same material, the same code, when implemented, can be used to connect with the Internet, to create on-screen visuals as well as fabricate three-dimensional installations.

4.7 (far left)
Bernard Cache and Patrick Beauce: *Topography* (2005) The Paris-based design/architecture studio *Objectile* combines engineering, mathematics, technology, and philosophy to produce designs at all scales from furniture to urban planning. Here is an example of a scale-less topography milled with computer numerically controlled (CNC) machinery.

4.8 (middle)
nybble-engine-toolZ installation at Ars Electronica (2003)

4.9 (right)
Margarete Jahrmann at Ars Electronica: Installation The vertical components are laser cut directly from their source code.

In other words, if the architectural expression is present as *code*, that is to say, is in the programming language as a set of instructions, then the new media expression of architecture is at once the code, the visual image on screen, and the resultant three-dimensional artifact. Whether the product or output is constructed by physical (human) or robotic (CNC—computer numerically controlled milling) methods is not crucial to the understanding of the concept. What needs to be underscored is not only a collapse of conventional formal definitions, but also an expanded view of architectural production as part of a process-based continuum. Furthermore, digital artifacts assume a place within a continuum that is not only theoretical, but also literal, inasmuch as artifacts are instantiated through code.

Case study
***nybble-engine-toolZ*:**
architectural intervention and mediapraxis[15]

> Take a lump of sugar: It has a spatial configuration. But if we approach it from that angle, all we will ever grasp are differences in degree between that sugar and any other thing. But it also has a duration, a rhythm of duration, a way of being in time that is at least partially revealed in the process of its dissolving, and that shows how this sugar differs in kind not only from other things, but first and foremost from itself.[16]

A system, though real, is nonrepresentational. A recent collaborative project designed by Austrian artist and theorist Margarete Jahrmann and artist Max Moswitzer is of particular interest because it was influenced by architect Bernard Cache's design philosophies and research practice. Cache studied at l'Ecole Polytechnique Fédérale de Lausanne and l'Institut de Philosophie, under the direction of Gilles Deleuze. His interests concerned spatial perception, especially how modes of representation could become problematized by space and motion, resulting in uncertain or unstable variations in form. As an interactive installation, *nybble-engine-toolZ* was developed in cooperation with the V2_lab Rotterdam and first installed at the exhibition "metadata" at the Dutch Electronic Arts Festival 03, and later constructed at Ars Electronica 2003, Linz, Austria, where it received an award of distinction.

The transmedia installation *nybble-engine-toolZ* in its abstract structural form is programming language operating as a set of instructions. This same code, while a constitutive part of the project, also acts in a dynamic relationship of information exchange. The code or digital material manifests in three different formal expressions—as static architecture in specific space, as projected real-time video, and as Internet portal. The installation's transmedia materiality is analogous with phase states, which indicate the phases present at a given temperature and composition, for example, H_2O's vapor, water, and ice.

4.10
Margarete Jahrmann and Max Moswitzer: *nybble-engine-toolZ* screenshots
The player is writing "peace" 73 times to <president @whitehouse.gov>

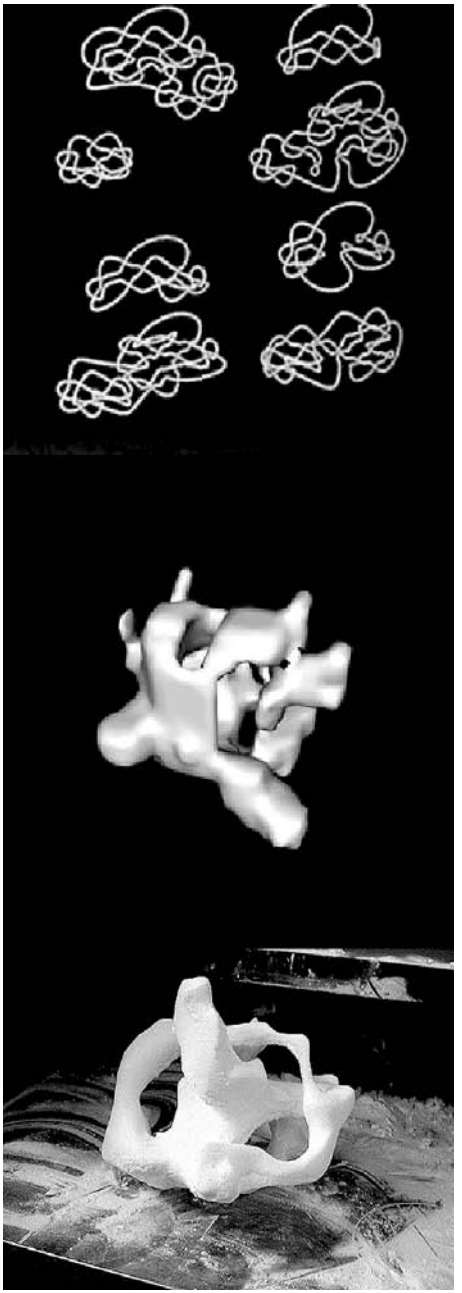
However, *nybble-engine-toolZ*'s approach is substantially different from water's phase transitions in that the digital media phases operate concurrently, that is to say, for the most part in the same space and time. As an architectural intervention, it is first a fixed physical space defined by material elements. While existing in a particular place and time, the installation, being transportable, is also non–site-specific. It is, second, an interactive digitally projected real-time video, and third, an Internet website, accessible throughout the world. And yet similar to a phase state, the formal properties of materials depend upon microstructure, in this case, code. In the absence of critical writing on the subject, the theoretical implications of new media installations as they relate to architectural expressions have been left largely unexamined. Therefore this discussion, and especially the various issues surrounding media specificity as related to the architectural image, are one way to generate further discourse rather than provide certain answers.

Jahrmann and Moswitzer's objective is to examine the postmodern (and pervasive) instrumentalization of vision and the formation of a viewing subject[17] (Chapter 2). Their installation stands as a critique of the economic colonization of the Internet by market interests, video game culture, and media sponsorship of war and violence. In an oblique reference to Picasso's *Guernica,* the artists take a subversive approach to the binary architecture of computer game activity. By reversing the effects of certain predictable video game actions, their installation became a kind of Situationist *detournement,* engendering a politically charged commentary on the violence in Iraq.[18]

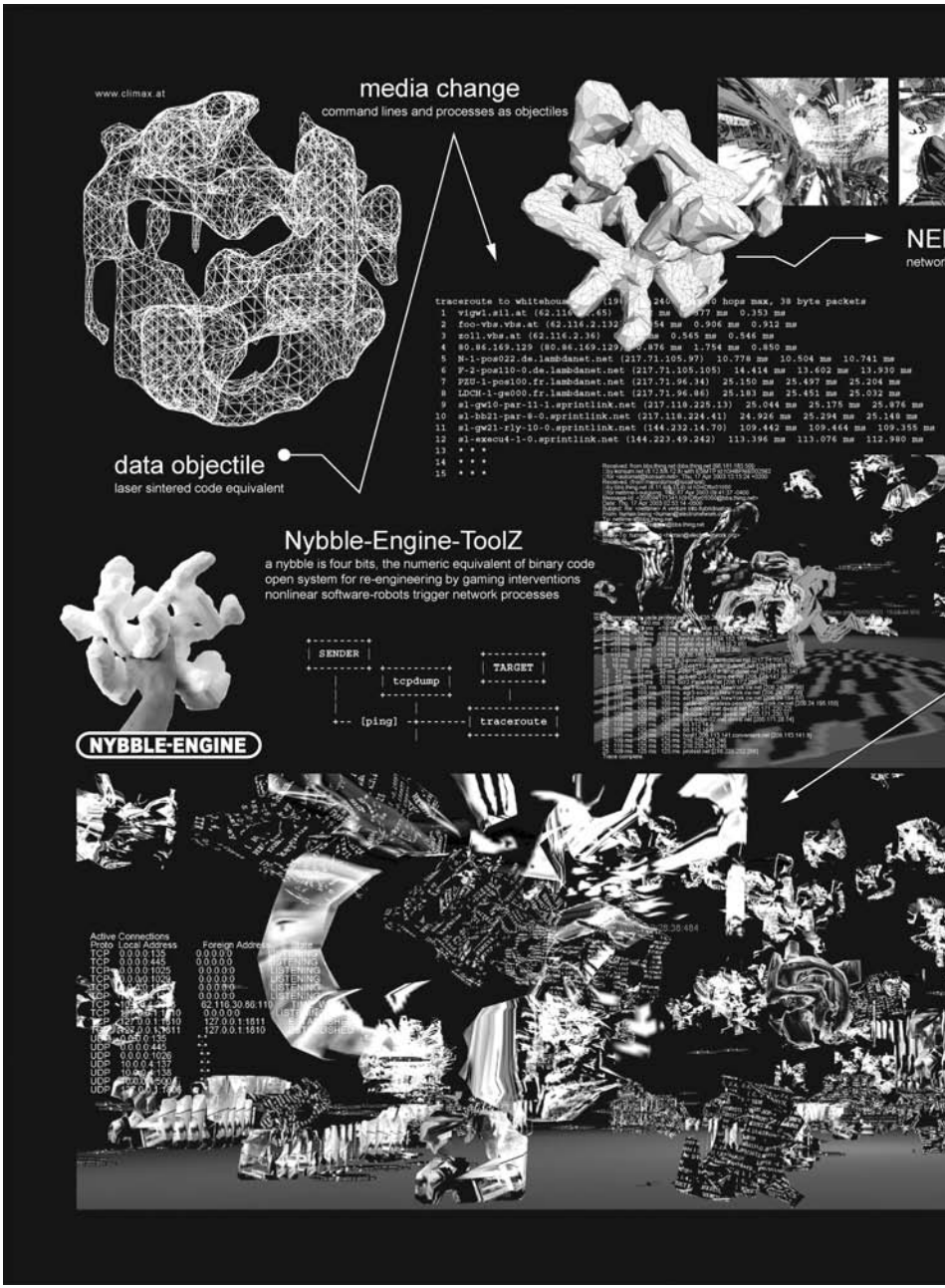
The installation is conceptually similar to a Deleuzian fold because, as an architectural intervention, its inside—the Nintendo Gameboy engine—transforms to its outside, by generating both the website and the physical installation. In a subversive response to commercialism and commodity culture, the artists hacked into a Nintendo Gameboy's software to reprogram it with new network commands.[19] Game play was completely reversed in that "attack response" generates collaboration between players, and "shooting" is then transformed into anti-war communication as emails to <president@whitehouse.gov>.

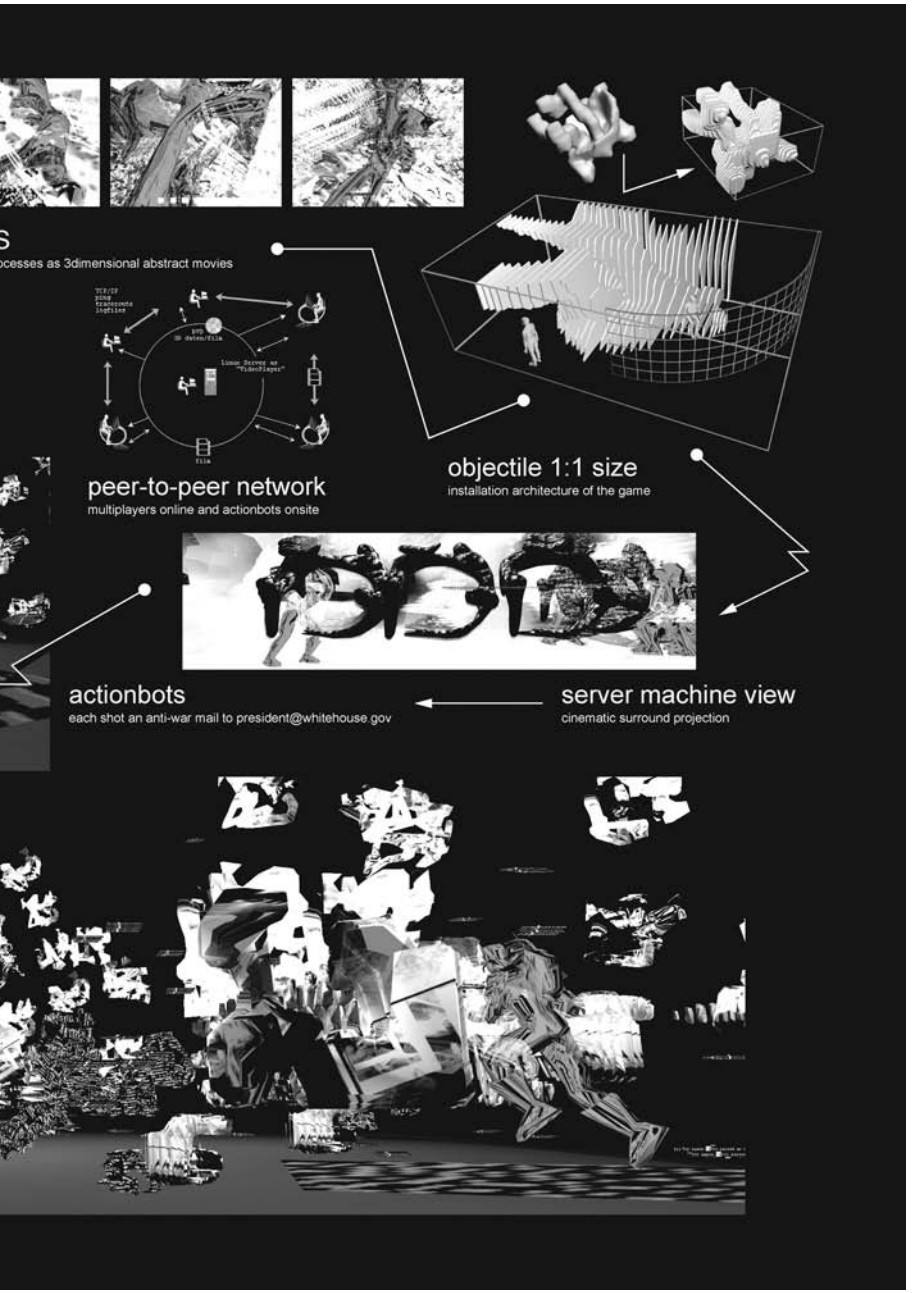
4.11
Pablo Picasso: *Guernica* (1937)

4.12
Objectiles in three translations: initial CAD sketches, digital model (on screen), and actual prototype fabricated with a 3D printer.



4.13
Margarete Jahrmann and Max Moswitzer: *nybble-engine-toolZ* (2003) Infographik describes media phases.




s
ocesses as 3dimensional abstract movies
peer-to-peer network
multiplayers online and actionbots onsite
objectile 1:1 size
installation architecture of the game
actionbots
each shot an anti-war mail to president@whitehouse.gov
server machine view
cinematic surround projection

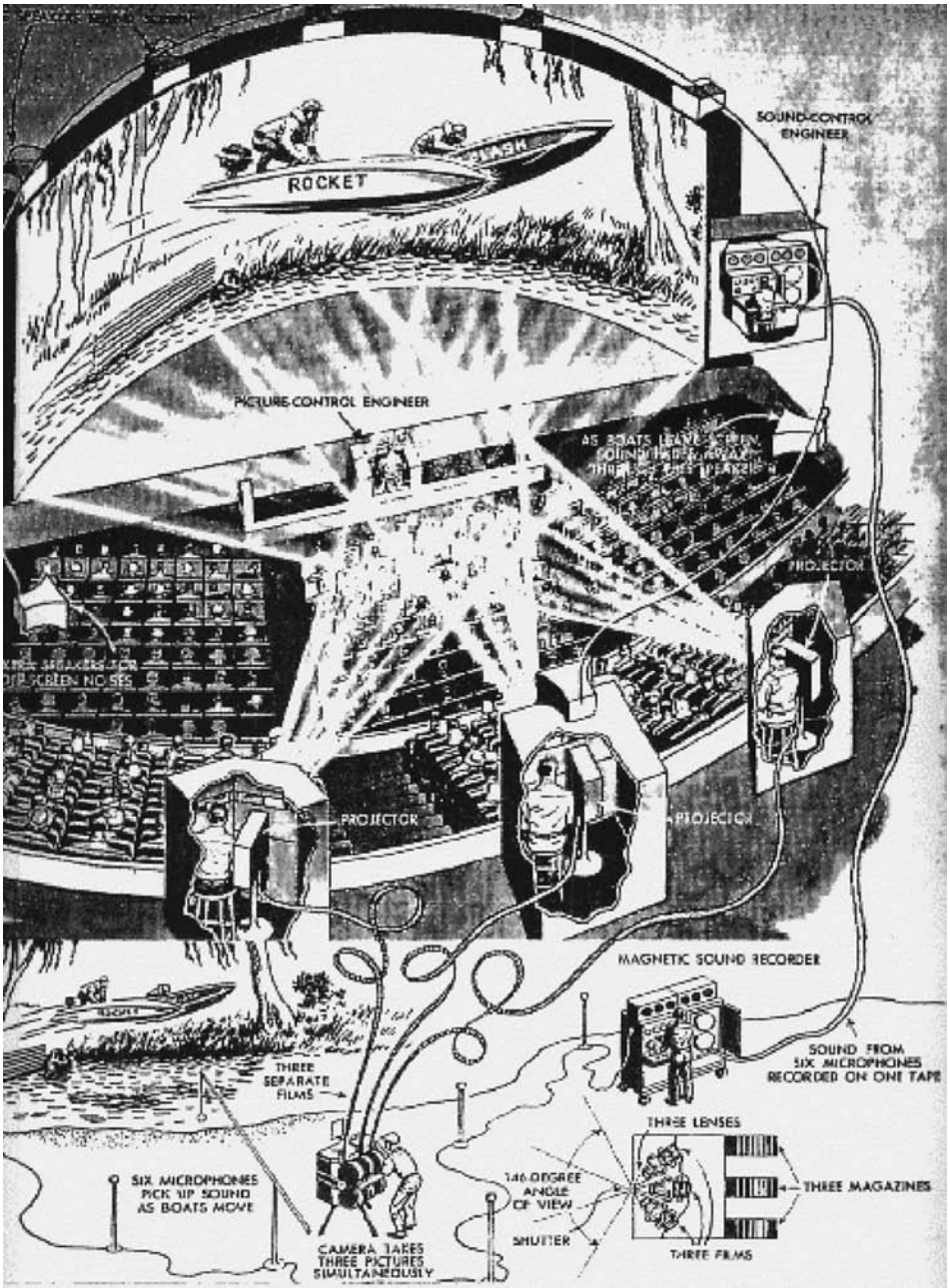
4.14
Media artists and theorists: Margarete Jahrmann and Max Moswitzer

As part of a large gallery or museum space, the installation resembles a vastly enlarged 3-D Gameboy virtual environment; it is constructed of multiple, vertical layers of shaped styrofoam panels. These forms are a trace of the movements made by subjects inside the networked environment. The digital information is translated into 3-D physical forms by utilizing CNC milling technology to sculpt large styrofoam panels robotically from program data at a 1:1 scale. Adopting Cache's terminology, Jahrmann and Moswitzer, call these forms *objectiles*. In reference to Deleuze, Cache defines an *objectile* as a very modern conception of the technological object:

> it refers neither to the beginnings of the industrial era nor to the idea of the standard that still upheld a semblance of essence and imposed a law of constancy … but to our current state of things, where fluctuation of the norm replaces the permanence of a law; where the object assumes a place in a continuum by variation … the object here is manneristic, not essentializing: it becomes an event.[20]

Within *nybble-engine-toolZ*'s installation space, because both virtual and actual are generated from the same code, the peer-to-peer software of the installation converts network processes into virtual three-dimensional abstract movies and then projects them onto a 180-degree screen, similar to Cinerama, which Jahrmann terms "interpassive." The network codes and commands are instantiated with the aid of game engines into audiovisual, *machinima* movies, being an actual merging of process and product.[21]

4.15
Cinerama Theatre architect: Ralph Walker, Voorhees & Walker (1937)
At the time, it was described as "startlingly real with a sense of environment and spatial relationship."



The activities of present and absent (online) players influence the environment. When shifting simultaneously between these positions, participants become <spectactors>, active spectators, changing between the interpassive and the interactive role of a player with code and a writer of code, between a visitor in an installation and an actor in a virtual environment. (The protean character of <spectactors> has a recent history; Roy Ascott used the term *participators,* while Bill Seaman called them *viewsers*.)[22] Furthermore, since distant emails are being continually sent into the nybble-game environment, additional variation is created as the messages are displayed in real time both as ASCII text and as newly generated objects. This change occurs at an alarmingly fast rate, as fast as the actions in video games.

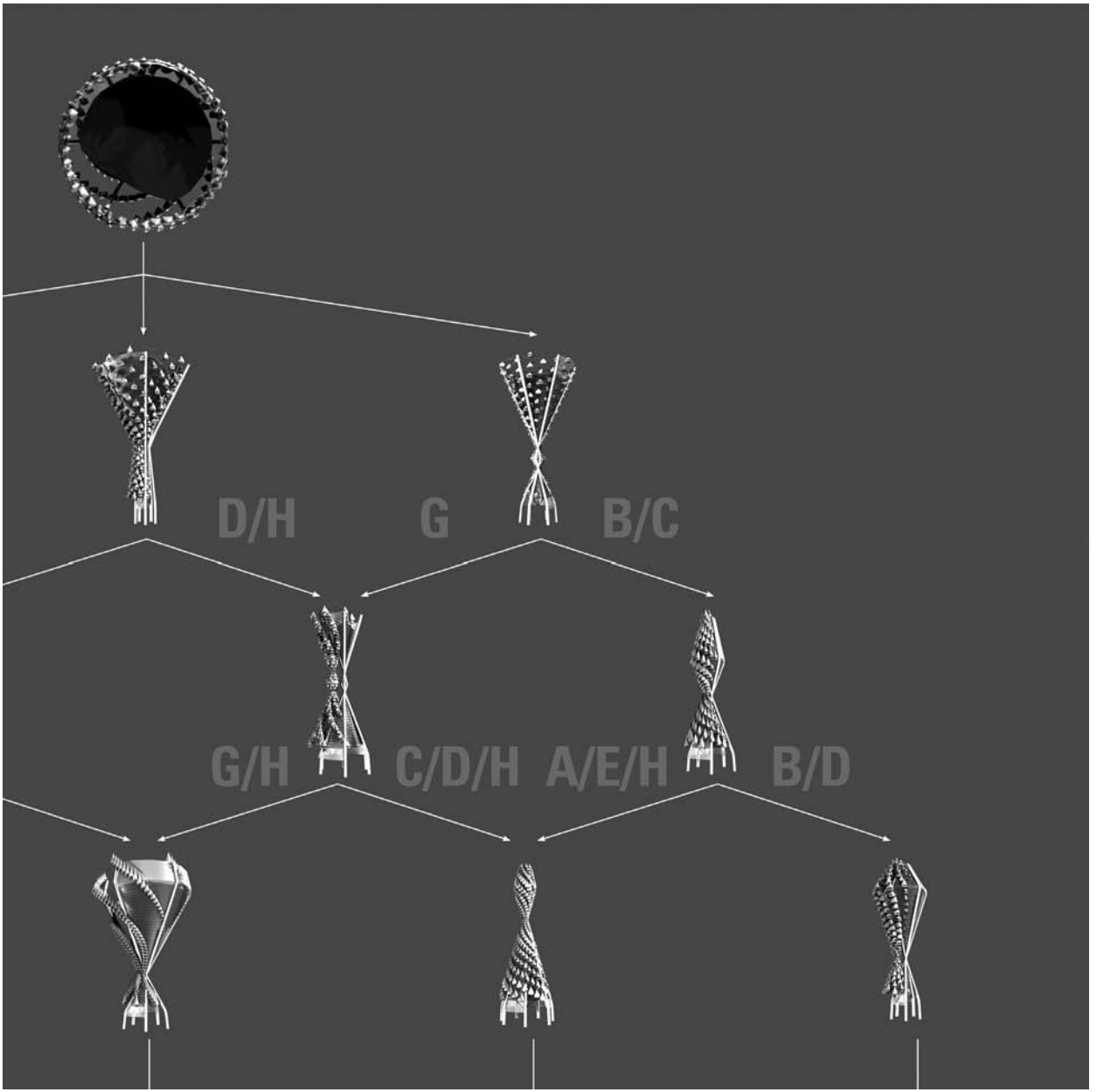
Jahrmann and Moswitzer employed political critique from what they term a *cyber-Nethical* point of view. They were influenced by the scientist and philosopher Heinz von Foerster, who introduced the term *KybernEthik*.[23] His writings address a second-order ethics, according to a second-order cybernetics, which follows the observation of the observation as a guiding principle. In contrast to the typically violent aesthetics of most computer games, *nybble-engine-toolZ* instead proposes actions linked to political engagement, by which ordinary citizens of contemporary democratic societies should be able to resist manipulation and control, as Noam Chomsky argues in his recent book *Media Control*.[24] Through the appropriation of commercial gaming technology, the collaborators have taken an ethical position regarding the media-event-space of war, most obviously the recent Afghanistan and Iraq wars of the early twenty-first century. *nybble-engine-toolZ* also references military video games and electronic war simulations, as well as the historical implication of architectural methods and technology with war and violence (Chapter 2).

nybble-engine-toolZ is also a commentary on Kantian aesthetics in that it intentionally reproduces aspects of the everyday that contrast with much of the glamorous or anesthetizing intent of commercial architecture. Typically, market forces appropriate art expressions for profit, whereas *nybble-engine-toolZ* appropriates commodity culture, thereby reversing the commodity into art. The installation, although an object in fixed space and time, resists its objectness through informational content and its multispatial overlay.

Cache, in some Deleuzian way, might argue that such intervention is ultimately medium-specific, since the same programming code was used to generate the CNC-milled physical and media installation, and the online play. With interactive installations, a blurring of medium distinctions has occurred through translation, because the same code instantiated all three expressions. Previously the notion of structure was embedded

within material; now, through computational methods, nonmaterial algorithmic rules have become the structure. A seamless condition exists between the code, the online visual images, and the physical installation.[25] Structure is delineated through information and organization. It is no longer possible to definitively mark where the digital image begins, or for that matter, ends. Now that the contemporary image is structured through programming code, the contemporary architectural image cannot be contained; it is diffused, mutable, and migratory.

Architectural interventions such as *nybble-engine-toolZ* leave architects in a position not only to design object/forms, but also to describe conditions of possibilities. These may be a response to social forces or intensities, and can be developed through numerous methods, only one of which is digital. However, what digital methods offer is the ability to process large amounts of data as field information and to map it in time interactively. This digital mapping is not a physical expression of architecture, but rather a description of a set of relations or the possibility of an architecture. In this manner, countless variations over time are possible, instead of just one. With the exception of the code, the image then has no essence, nor constancy. While determinacy evaporates, such a model offers a precise indeterminacy.[26] It is an alloplasticity, an open description, a reciprocal relation between environment and self.


D/H
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G/H
C/D/H
A/E/H
B/D

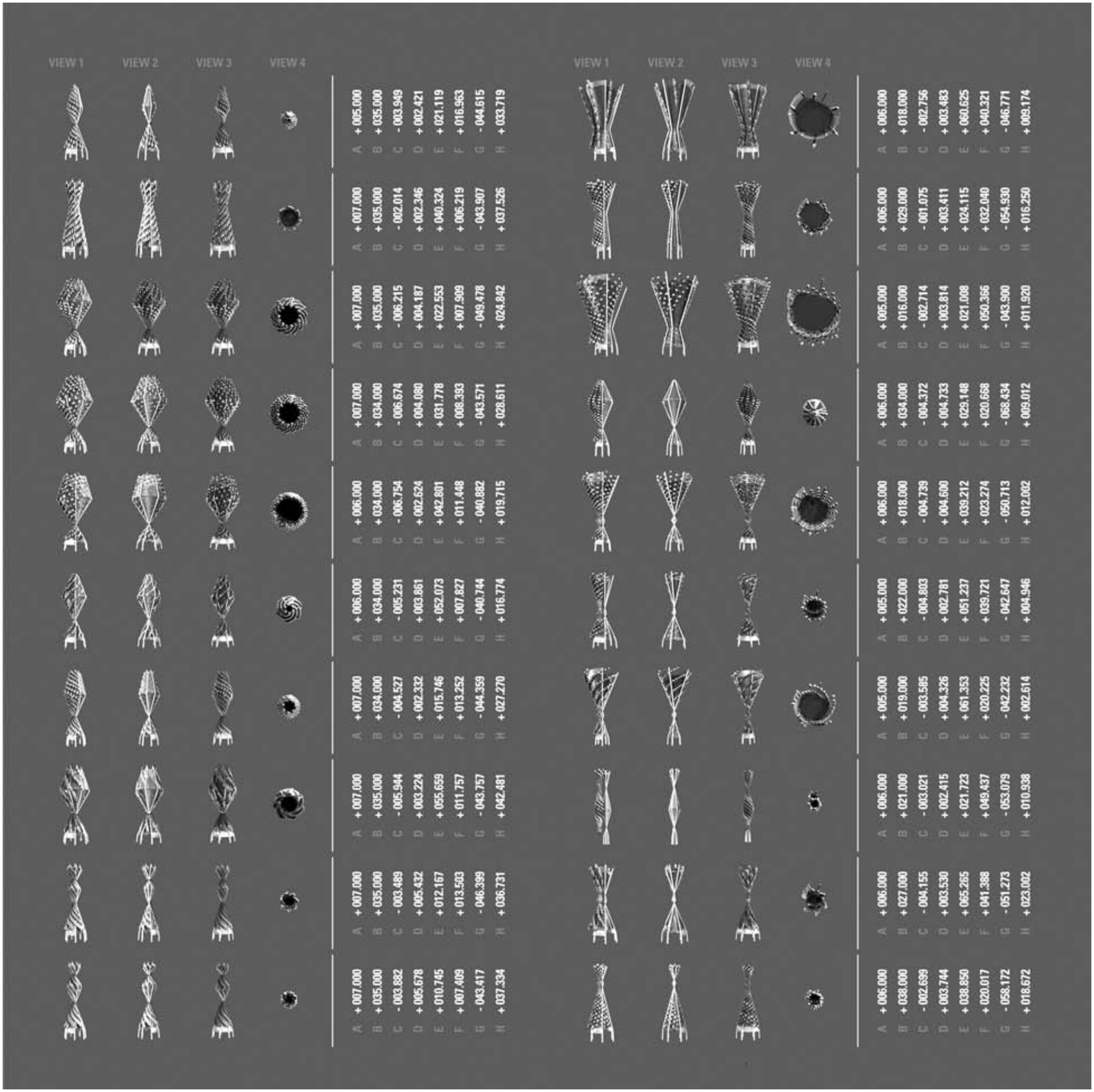
5
Generative systems

Evolving computational strategies

5.1
Joshua Dannenberg and Chris Schusta: *Metacity Lagos-Loop* (2006) (detail) This scheme employs a looped computer modeling code that builds, renders, and organizes numerous skyscraper options. These options then self-segregate into a formal pedigree varying in texture and performance.

Design, as understood broadly, is concerned with the process of form. Design research involves the integration of explicit and systematic connections between the formal attributes of an artifact and its social parameters, as well as its structural performance. In addition to form-making, design is concerned with cognitive processes and subjective decision-making related to the production of form. This is acknowledged within architectural design as incorporating rational systematic analysis as well as subjective interpretation.[1] A synthesis of design logics—what could be termed "multi-logic"—occurs at the interface between rational and nonrational methods, and constitutes a highly productive ground for design investigations.[2] In fact, many generative design methods seem to recognize this; rather than a set of autonomous actions, they rely on multiple iterations and feedback between agents, parts, and systems in a dynamic interactive process.

Granted, all design methods, whether analogue or digital, instill an ordering, a discipline as it were, to the process. Conflict only arises when methods are counterintuitive or overly restrictive. While it has been acknowledged that the mental structure of the designer and the functional structure of the software are different,[3] any systems or computational approach involves a linear progression and a parts-to-whole schema, requiring designers to break the problem down into subsets, sometimes resulting in premature or restrictive decisions.[4] The creative tension then arises between the apparent reductionism inherent within computational methods and the new complexities possible through dynamic modeling and form-generating software.

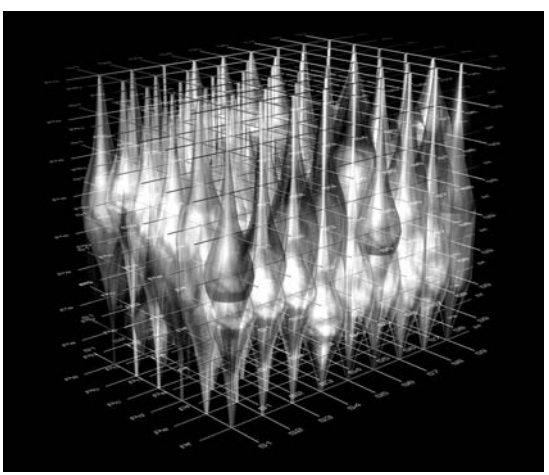

VIEW 1
VIEW 2
VIEW 3
VIEW 4
A + 005.000 B + 035.000 C - 003.949 D + 002.421 E + 021.119 F + 016.963 G - 044.615 H + 033.719
A + 007.000 B + 035.000 C - 002.014 D + 002.346 E + 040.324 F + 006.219 G - 043.907 H + 037.526
A + 007.000 B + 035.000 C - 006.215 D + 004.187 E + 022.553 F + 007.909 G - 049.478 H + 024.842
A + 007.000 B + 034.000 C - 006.674 D + 004.080 E + 031.778 F + 008.393 G - 043.571 H + 028.611
A + 006.000 B + 034.000 C - 006.754 D + 002.624 E + 042.801 F + 011.448 G - 040.882 H + 019.715
A + 006.000 B + 034.000 C - 005.231 D + 003.861 E + 052.073 F + 007.827 G - 040.744 H + 016.774
A + 007.000 B + 034.000 C - 004.527 D + 002.332 E + 015.746 F + 013.252 G - 044.359 H + 027.270
A + 007.000 B + 035.000 C - 005.944 D + 003.224 E + 055.659 F + 011.757 G - 043.757 H + 042.481
A + 007.000 B + 035.000 C - 003.489 D + 005.432 E + 012.167 F + 013.503 G - 046.399 H + 036.731
A + 007.000 B + 035.000 C - 003.882 D + 005.678 E + 010.745 F + 007.409 G - 043.417 H + 037.334
VIEW 1
VIEW 2
VIEW 3
VIEW 4
A + 006.000 B + 018.000 C - 002.756 D + 003.483 E + 060.625 F + 040.321 G - 046.771 H + 009.174
A + 006.000 B + 029.000 C - 001.075 D + 003.411 E + 024.115 F + 032.040 G - 054.930 H + 016.250
A + 005.000 B + 016.000 C - 002.714 D + 003.814 E + 021.008 F + 050.366 G - 043.900 H + 011.920
A + 006.000 B + 034.000 C - 004.372 D + 004.733 E + 029.148 F + 020.668 G - 068.434 H + 009.012
A + 006.000 B + 018.000 C - 004.739 D + 004.600 E + 039.212 F + 023.274 G - 050.713 H + 012.002
A + 005.000 B + 022.000 C - 004.803 D + 002.781 E + 051.237 F + 039.721 G - 042.647 H + 004.946
A + 005.000 B + 019.000 C - 003.585 D + 004.326 E + 061.353 F + 020.225 G - 042.232 H + 002.614
A + 006.000 B + 021.000 C - 003.021 D + 002.415 E + 021.723 F + 049.437 G - 053.079 H + 010.938
A + 006.000 B + 027.000 C - 004.155 D + 003.530 E + 065.265 F + 041.388 G - 051.273 H + 023.002
A + 006.000 B + 038.000 C - 002.699 D + 003.744 E + 038.850 F + 020.017 G - 058.172 H + 018.672

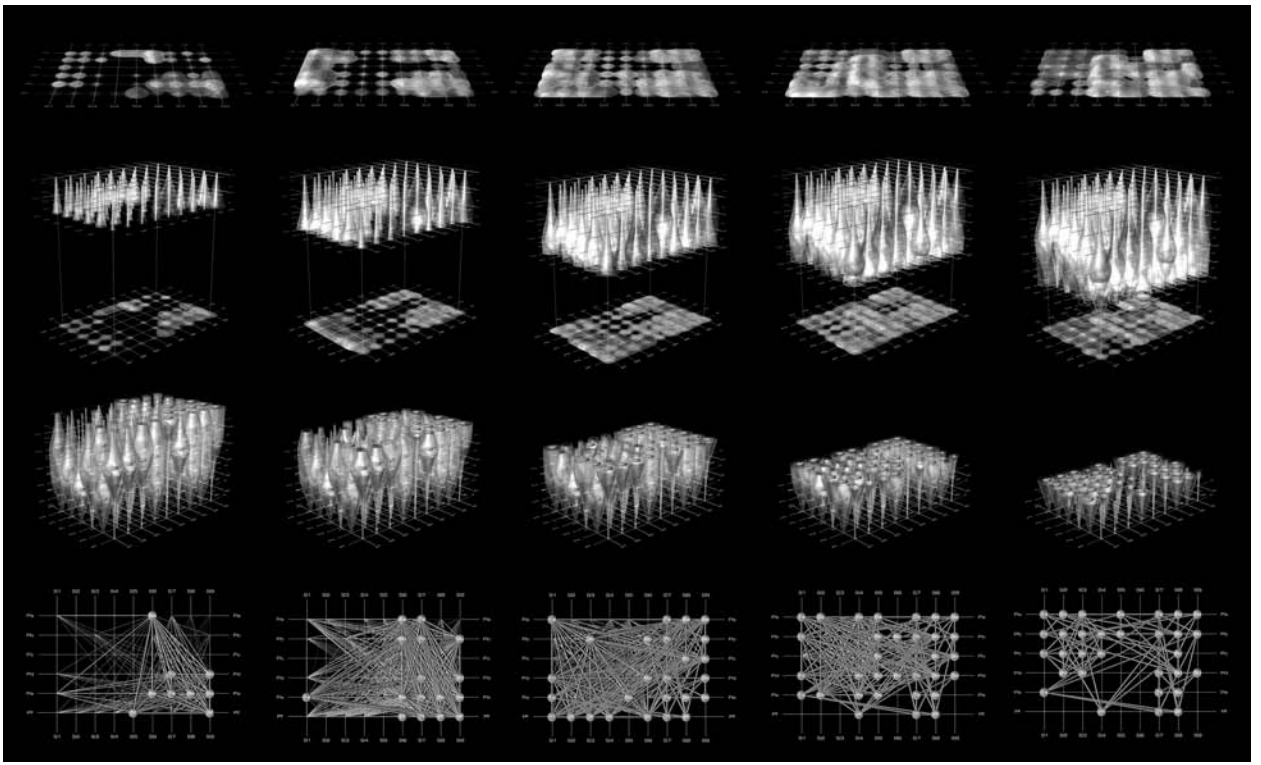
5.2
Joshua Dannenberg and Chris Schusta: *Metacity Lagos-Loop* (variables) (2006)
Using a discrete set of parametrically controlled code variables, the Loop draws its predictable and unpredicable complexity to yield numerous quality outputs.

5.3
Achim Menges: *Postagricultural Project* (2004)
Organizational model of differential intersystemic relations.

If First Generation design theorists (Bruce Archer, Herbert Simon, *et al.*) were concerned with how to rationalize the architectural product, then the Second Generation (Horst Rittle, Donald Schon, *et al.*) redefined the field by stressing the social aspects of design. Today, a number of contemporary architectural theorists, primarily Jeffrey Kipnis, Markus Schaefer, and Michael Speaks, display a tendency towards shifting research in the direction of a more integrated approach. Instead of received truths from philosophy, postmodern, or poststructuralist theory, their conclusions are drawn from architecture's interiority, that is to say from within the architectural design processes themselves.

Since the 1990s, the context of architectural design has undergone significant change, primarily as a result of global economic pressures and the Internet. As architecture has become more complex and hybridized, the design process has evolved into much more than simply problem-solving; it necessitates research that is ongoing, collaborative, and experimental. Speaks believes that what architects have to offer is their design intelligence. He suggests that in the context of an increasingly complex global environment, economics and the sciences play a large part in today's design research.[5] Unlike in the mid-century design environment, invention and innovation are viewed as different from problem-solving. Today's architects design their own software, implementing advanced computational methods, and create data visualizations that make complex information more accessible.





5.4
Achim Menges;
Postagricultural Project
(2004)
Digital mapping technique of a system-specific light and climatic conditions.

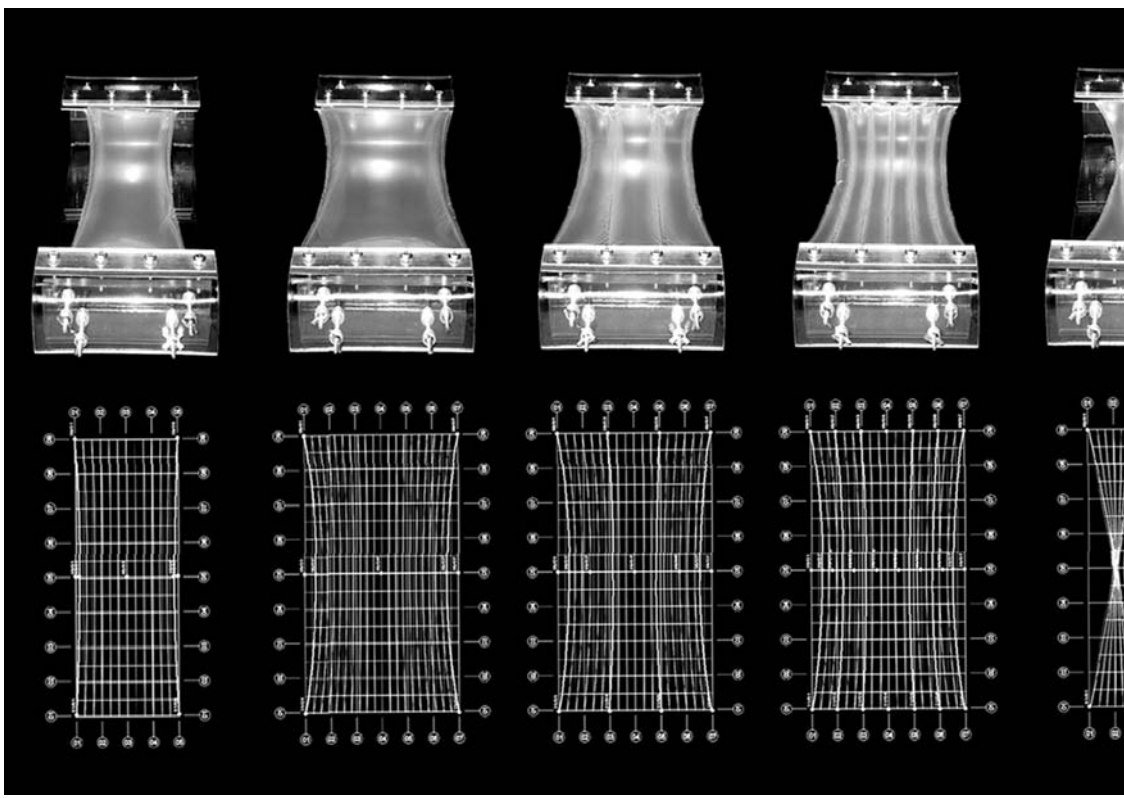
Definitions

Within this transitional context, the research discussed here intends to build on the applications of rational systems to the evolution of software objects—specifically form generation—as an *assist* to architectural design related to the architectural image. To date, most discussions related to digital methods have concerned themselves with the technological components, the hardware and software. However, with few exceptions,[6] less has been written situating these new digital methods within a theoretical design framework as they relate to architectural expression and design production. Design in this instance is seen as a cognitive inventive process, where the focus is on the *interaction* of the designer, decision-making, and control with the digital artifacts. Aesthetic valuations are outside the scope of analysis. Furthermore, references from the biological sciences in regard to morphogenetic processes are not employed in this instance as metaphors or analogies, but instead as methodological models whose operative principles may be useful in the understanding of a more complex computational approach to design.

The three most pressing issues directly related to the status of the architectural image appear to be, first, the reductive effect of instrumentation on problem formulation and solution, including the predictive aspects of rational systematic design methods; second, the ontological implications of digital material; and third, the notion of developmental change in relation to the architectural image.

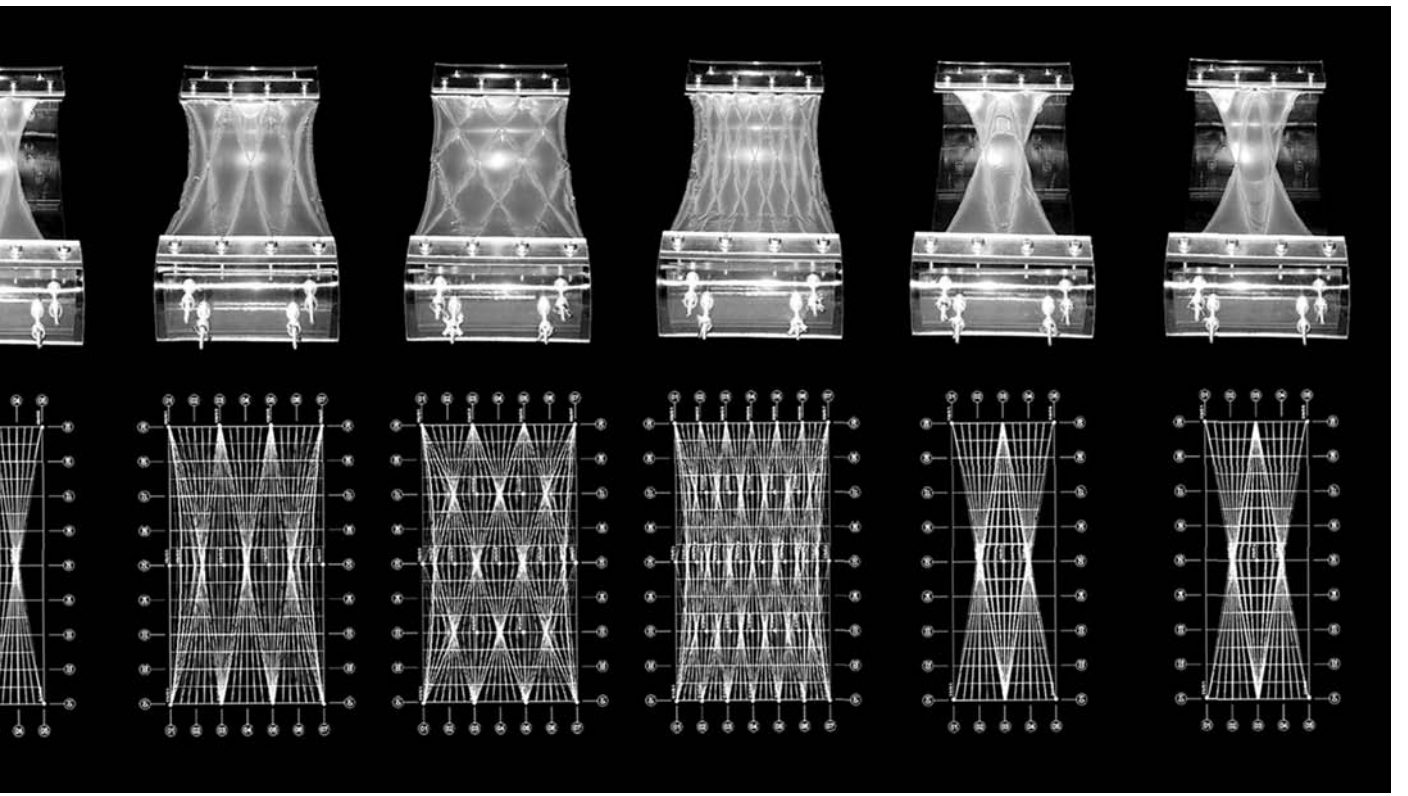
Designing rules

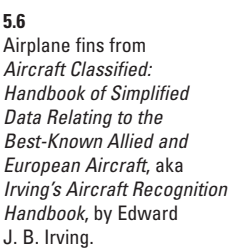
Designers use other media to produce expressions of artifacts, rather than the actual artifacts themselves.[7] Modeling software is one such productive tool for the generation of virtual models through three-dimensional modeling programs (*Rhino, Maya, Soft Image, GENR8, <catching fish>*), digital scanning (*Catia*), and computer numerically controlled machinery (*CNC, CADCAM, 3D printing*) for digitally robotic-produced artifact/models and rapid prototyping. Scripting languages, including MEL/*Maya*, can be combined with existing software. Some clarification of terms is necessary before proceeding, not only because the computational design process is insufficiently understood by most laypersons, but because the terminology is still relatively undefined even among architects.



5.5
Achim Menges:
Postagricultural Project
(2004)
Component evolution based on parametric variations of the boundary definition points, the seam layout, the pressure of the compressed air volume, and the consequent geometry and prestressing of the membranes.

First, digital software *assists* in the design process, and is not a tool performing the design by itself. The computational methods described herein do not result in autonomous designs. Second, they are not advocated in all design applications, but only where the solution field is appropriate. More importantly, computational methods can be used for other purposes within the solution field, such as data organization and analysis, in multiple platforms and multiple locations in the design file. Third, these methods are experimental and their future applications are not fully known. Finally, this chapter emphasizes only one aspect of the design process, which is the schematic phase of form generation. Therefore in the proposed virtual model, evolution corresponds to the belief that design domains are open-ended; that future needs cannot be completely anticipated; and that some problems are by nature ill-structured and require trial and error exploration.[8]





5.6
Airplane fins from *Aircraft Classified: Handbook of Simplified Data Relating to the Best-Known Allied and European Aircraft*, aka *Irving's Aircraft Recognition Handbook*, by Edward J. B. Irving.

Within the design solution field (also called a conceptual field), theorist Vinod Goel[9] recognized that computational methods result in an instrumentalization of the design process, since they require certain protocols and ways of thinking, just as analogue tools do. The very nature of writing code necessitates a reduction of information because it involves a reformulation from diagrams to symbol strings (mathematical notation and/or programming language).[10] With a few exceptions, current software lacks sufficient flexibility, but this position will continue to improve as new interfaces are developed that respond to the cognitive patterns of visually/spatially-minded designers. Typically, the architectural designer must cognitively adapt to the requirements of the program over time.[11]

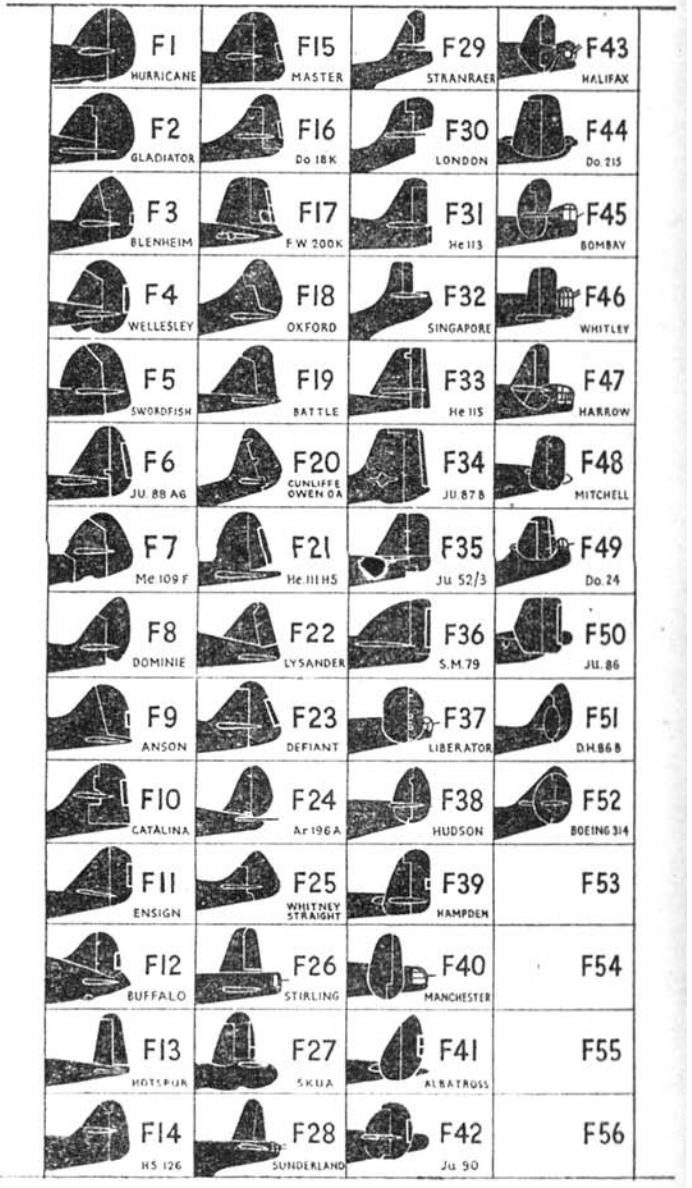
Design researchers have emphasized the need to integrate problem framing and problem solving.[12] Therefore the important task is to select a digital application that will adequately address the given solution field, that is to say where a systems approach is appropriate. If the solution field is viewed along a gradient where design implications vary in their consequences, then computational methods for form generation are most successful in partially closed systems.

Computational design research

In regard to generative form and parametric design, there is still much discussion about parametric design, and what it means for architecture is still being explored. The term originated with engineering; it refers to a mathematical formula that requires values to be substituted for a few parameters in order to generate variation from within a grouping of entities. Today, in practice, it yields the finding that once an entity has been documented symbolically, that is to say mathematically, it can be easily changed without altering its entire structure. Parametric entities carry their attributes and properties within their symbolic representations. This then allows them to be manipulated and transformed in relation to these properties. If we compare this method to an analogue process, individual elements of a structure are studied and manipulated, and evolve as the whole structure evolves.

With this in mind, the intention is to first analyze an industrial design software program with a clearly defined solution field, which incorporates some interpretive or subjective levels, into evolutionary generative processes. Although the program has constraints, they are interactive in their generative processes, and exploratory in that the final results are not clearly known. Evolutionary generative form programs offer designers greater intuitive involvement, in addition to a conceptually open-ended approach. Through the

FINS & RUDDERS



integration of rational and nonrational methods, these programs point the way toward innovative design methods of form-making.

While the focus is on form generation within parametric design methods, it must be noted that all design methods exhibit a tension between their constraints and their freedoms. What is significant, however, about evolutionary form generation is that the software designer's intention is to actually *increase* the chance of random occurrences resulting in many more possible versions. Complex systems allow the designer/user to act as an editor and to apply intuitive, divergent, or aesthetic choices so as to both manipulate the model and develop additional options (or offspring), and subsequently select from among them. In that sense, one could venture that virtual or potential qualities can emerge from the interaction between these systems.

If earlier theorists characterized mid-century computational methods as reductive, is it possible for today's parametric design to be understood as complexities in variation or flux? For the analogue designer, there is no difference between thinking and doing; new situations are always being explored with each action and iteration. With computational operations, the single master symbol prototype is displaced by many prototypes or iterations over time. Does the act of production itself become an active generator? Is the program truly capable of producing an endless series of specific permutations that respond to and integrate various parameter inputs? How much creative agency or choice does the designer actually have?

Evolutionary design methods

The structure of form-making within computational strategies has divergent directions; here, in this instance, the software program to be analyzed is primarily form-generating rather than form-finding (component level), or relational dynamics (animated simulations). *<catching fish>* was developed by Markus Schein for industrial design applications and is discussed in "The Methodological Approach from a Designer's Point of View," (2001). For analysis, the methods used to reach a proposed design solution will be reviewed below.

In preparation, the designer initially identifies the elements of his or her subjective ideas. These elements are then translated into a generative code using genetic algorithms, which allow for the management of increasing complexity as well as the application of the code to various design solutions.[13] Natural evolution is taken as the methodological model, with steps toward optimal form-making guided by the designer as she or he manages the generative design process.[14] The designer works interactively with the program. Because of the uniqueness of each design problem, the unpredictability of the results, and the subjectivity of the process, Schein suggests that it is possible neither to define rules for form generation nor to determine exact criteria of selection for the newly generated forms. These are variable and responsive to individual and particular design goals:

Basic structure of design tasks

Definition of the problem field
Determination of criteria of selection
Definition and modification of rules for form generation
Development of n models
Evaluation by designer/user evaluation (back to task 2).

The software therefore is always dependent not only on the system that is enacted, but also on its designer/receivers. These tasks create an iterative, recursive process beginning with the establishment of parameters or rules, which are then used to generate models, followed by an evaluation stage providing feedback, which is then further used to refine the parameters. Through feedback, the design evolves. In this sense the software interface affords a dynamic, interactive, and responsive process between designer and program.

Fig. 3

5.7
Haresh Lavani, concept and design: *Evaluation: Algorithm Prototypes* (1997–99)

The structure and organization of form generation

The designer typically proceeds by entering data straight into the modeling program. Parameters are established volumetrically to scale. This organization of the digital model affords an analogue competence—that is to say, it can be modified as can a sketch—and then generates numerous iterations. The obvious advantage is that the design object is seen directly as a whole; it can be further studied and evaluated through simulations. Another feature is that cross-sections of different models can be grouped together to create composites of new three-dimensional forms. Additionally, any generative "event" can consist of one single form or multiple forms. As more forms are generated, spatial relations between forms can be delineated and manipulated.

Settings for constraints

Morphing and proportional scaling are variables that can be adjusted to respond to performative criteria. Programmatic requirements and/or planning codes are other factors highly influential in determining the constraint settings. Any new or additional information can be incorporated into the model through morphing without altering the entire form. Even more important, the designer is able to observe the model adapting to its constraints in a simulated environment. It is also clear that the designer's decisions may be based on conceptual objectives or aesthetic concerns. Some of the more advanced engineering software programs incorporate structural performance criteria so that dynamic forces can be analyzed in relation to the load-bearing capacities of the proposed physical or material structure, for example, with Bentley Systems.

Evaluation

A crucial stage is related to interpreting results. The notion behind multiple generations is to observe the enacting of a performance where the animation of differences plays out in order to better understand the characteristics of the object/form being investigated. The term, parameterization, means to view the resolution as the parameters and to pick one specific case area from within those parameters.

It is commonly believed that the selective procedure used here is a merely a subjective aesthetic decision made by the designer. While this means that the criteria of selection are not implemented by the program but instead involve intervention by the designer, subjective criteria are not the only ones used. As explained under constraint settings, there is more at stake here than mere aesthetics, most especially performative requirements such as programmatic responses and structural capabilities. The designer's role is to interpret the data, to place a relative value on the characteristics by creating a hierarchy of affordances.

The designer then decides which generative event or events shall become parents of the next generation. These actions are separate from the constraints. At this stage, there is potential for the designer to develop his or her own designs in a less analytical, more divergent and subjective way. A further potential exists for the generation of forms that were not predictable initially.

Evolution via the software program

The digital platform or program manages generative design processes. First, there are an incredibly high number of solutions to every design problem; and, second, the right set of criteria toward an optimal solution cannot be completely described before the solution comes into existence, that is to say before the solution is arrived at. This is in agreement with Rittel's findings that the solution cannot be removed from the problem formulation. Design is not purely causal, but integrated.

At the same time, the goal is not necessarily that the original forms actually converge according to the defined optimal criteria after a number of generations. What is more important, in my observation, are the intermediary stages of digital models: each one has the potential to allow the user to discover new and unexpected avenues toward an improved quality of his or her design. Control of mutation is also provided, so that the designer can manage quality and quantity of allowable or prescribed changes between subsequent generations.

Other program functions in the computational solution field:

– *View options*
  This allows the designer to view and evaluate options.
– *Sketching space*
  The way the constraint data or parameters are entered will allow for the direct translation of either gesture or drawing movements into the constraint settings.
– *Library or extended memory*
  This important function allows for data organization of formal information.

Constrained randomness

In order to begin the design process, the designer enters the currently known requirements, as well as his or her ideas about the design problem, into the program by creating a new constraint structure to restrict the space of possibilities for form growth. Everything that the designer left undecided, or might have forgotten to decide, is decided randomly by the software. The random settings and the degree of tolerances left by the designer allow for necessary freedom within the generative process, resulting in unpredictable or unforeseen results.

If the desired result was not achieved during the first series of iterations, the designer can either tighten up the constraints or loosen them to generate the next sequence of events. Restarts, or newly composed iterations, are constructed with a selection from one of the earlier models or a recombination from the data library. Each generated model can then be taken out of the process at any stage or sequence in order to laser-cut physical models or to render it graphically.[15]

Analysis of evolutionary computer-generated design methods

Linear problem-solving models typically described a closed boundary problem. With current form-generation software, complexity in form, movement, and time accompany the solving of the problem. Evaluation and argumentation, whether collaborative or internal within the designer's mind, are a critical part of this process. Design researchers, following Rittel's conception of a dynamic problem space, need to resist the fixity of contents, which otherwise leads to reduction on both individual and global levels. With generative software, the conceptual field is modifiable and adaptable, and solutions occur through recursive feedback over numerous iterations.

As demonstrated, design problems are never purely algorithmic, although they incorporate algorithmic components. In actuality, the designer subject is embedded within the decision-making options of the program. <*Catching Fish*> is a simple program, yet it overlays rational programmatic systems with human subjectivity and intervention. There is continual interaction on the part of designer, not only in the performance of prescriptive actions, but also in adjustment of the flexibility of parameter settings, which allows further modifications.

Can we say definitely that the parameters have been relaxed? Certainly. Is the process open-ended? This is less certain. It is open-ended in that the designer achieves

unanticipated results, which aren't known entirely in advance. Yet this is still a mathematical system with constraints described through algorithms. Variety is achieved through the high number of permutations available for study or reflection. These are probably not innumerable, however. The issue of control seems to crop up repeatedly as well.

From analysis, <*catching fish*> operates as a multidimensional morphological matrix, which can be further modified at various evolutionary levels. The morphological approach was developed by California Institute of Technology astrophysicist Fritz Zwicky in 1966, as an alternative to mathematical methods and causal modeling. His objective was to add a qualitative dimension to evaluation models by relying on valuation and internal consistency, rather than simple causality.[16]

> Attention has been called to the fact that the term morphology has long been used in many fields of science to designate research on structural interrelations—for instance in anatomy, geology, botany and biology ... I have proposed to generalize and systematize the concept of morphological research and include not only the study of the shapes of geometrical, geological, biological, and generally material structures, but also to study the more abstract structural interrelations among phenomena, concepts, and ideas, whatever their character might be.[17]

His approach, "General Morphological Analysis: A General Method for Nonquantified Modeling," begins by identifying and defining the dimensions or parameters of the problem space to be investigated, and assigning each of these a range of relevant "values" or conditions. It was based on the principle that illogical or nonrational combinations have the potential to be useful solutions. Because of recent advances in computational technology, many of his theories, especially in regard to policy analysis and future studies, have been reintroduced. As with any morphological matrix, for example <*catching fish*>, there are still parameters, but they have been greatly expanded.

Nonstandard organizational logics

In contrast to the evolutionary form-generation programs discussed previously, there are other computational methods related to emergence and self-organizing systems, which are termed advanced component or bottom-up logics: fractals, self-similarity, and aggregated systems. These methods have been comprehensively described by Michael Hensel, Achim Menges, and Michael Weinstock, in their research with the Emergent Design Group at the Architectural Association.[18] As such, these methods are not the focus

of this chapter. However, their work represents a significant direction for the future of design research by proposing a nonstandard organizational logic.

In describing emergence as it exists in the material world, the neuroscientist Benjamin Libet suggests that the phenomena displayed by a system may not be evident in the properties of the sub-units that make up that system. For example, the properties of a wheel are not evident from the properties of the materials used to construct the wheel. The wheel's property of rolling emerges from the system, created by the specific arrangement of the materials used to make the wheel.[19]

In this manner, parameters define relationships between components to determine the formal joining of primitives, for example, with Voronoi diagrams or cellular aggregated approaches. Simple combinatory rules can result in self-organizing systems with great complexity. With form-finding methods, components can also reflexively respond to various conditions, resulting in unforeseen configurations. Indeed, the greatest potential of emergent design methods seems to lead to the development of flexible and adaptive structural systems that are able to change in response to contextual and programmatic change.

At the more experimental end of research, Peter Testa and Devyn Weiser, founders of the Emergent Design Group, at MIT, California, are attempting to cross disciplinary boundaries by creating a dialogue with the sciences. While component-level optimization has been established in the literature and within engineering disciplines, Testa's research also synthesizes a bottom-up strategy for architectural design. His computational design approach extends well beyond optimization; instead, he regards form, materials, and structure, not as discrete elements, but as acting on each other in self-organized hierarchies. Two of his programs, TOPO and GENR8 (Generative Form Modeling and Manufacturing), are surface modeling programs that combine artificial intelligence and complex feedback loops. The program GENR8 is based on natural growth systems within a dynamic shaping environment/infrastructure and a localized application of automated processes. The program has applications outside of architecture or planning; more importantly, from this method design solutions are generated that are unforeseen.

Iterations and feedback

One could suggest that design research has arrived at an expanded empiricism. Upon further reflection, however, the designer, whether architect or industrial designer, still needs to deconstruct the generative phenomena into an ontology of forms, a design context, and a materiality.

5.8
Achim Menges:
Postagricultural Project
(2004)
The differentiation of material systems offers the possibility of developing an architectural approach that integrates ecological, topological, and structural performance.

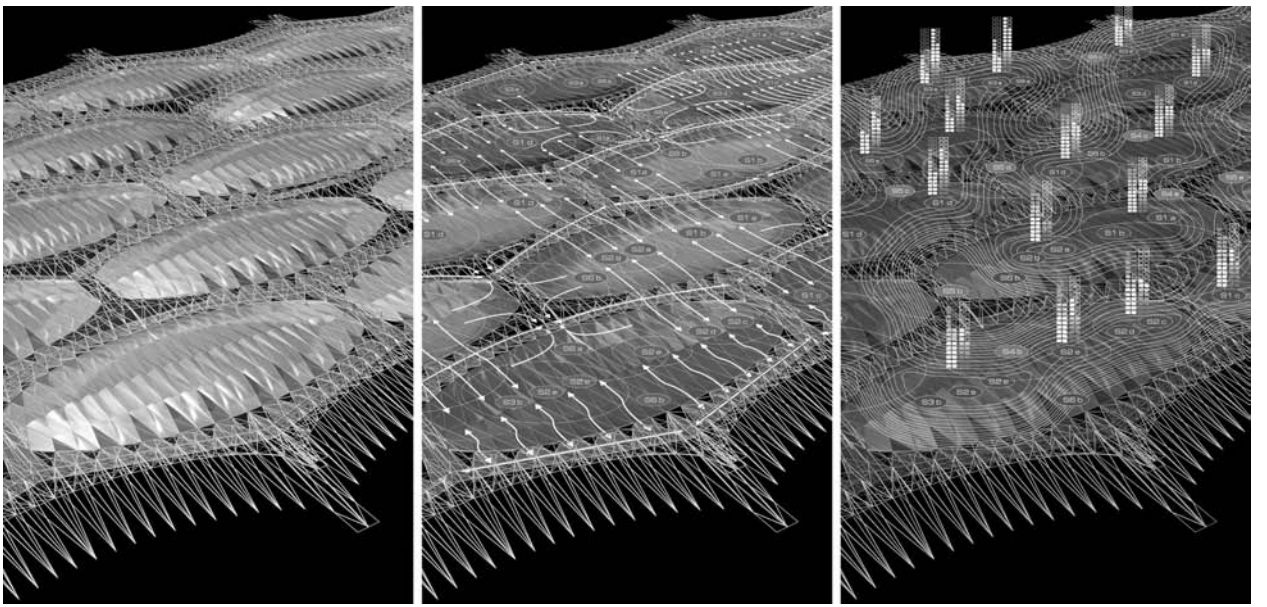
During the process of data entry or formal description of the original parent entity, the model goes though a transformation from iconic (analogical sketch) to symbolic (mathematical) expression, that is to say the architectural image has changed from icon to symbol. While the symbolic image has gone through quantifiable translation, it is ironic that the symbolic or digital model still contains more complex information, because it incorporates the fourth dimension of time. There exists an inherent tension with generative design software between the reductionism of computational methods and the complexification of algorithmic processes, brought about through developmental or evolutionary change over time.

The software also gives rise to a cognitive model that is developed over a period of time, through a process of familiarity and adaptation, which affords more ease of use. While still incomplete in analysis, the primary focus of this chapter has been on the *interaction* of the designer with the digital artifacts, as well as their cognitive decisions that result in formal recombinations and revisions. In this analysis, computational methods and the resultant digital image realization have been explored both as a process *and* as a way of thinking. As part of an ongoing investigative design process, generative software allows alterations that were previously possible only with great difficulty with earlier CAD programs and analogical models.

Formalism

As both classical and modernist architecture staunchly testify, analogue methods produced their own brand of big box formalism, so it also seems inevitable that a type of digital formalism has resulted from the use of modeling software. It is these various formal issues that might lead one to conjecture whether the program's evolutionarily generated forms are object-based, that is to say, are the designer's efforts still focused primarily, although not exclusively, on formal concerns with the end result of a contextless artifact?

One interpretation is that many industrial design/engineering programs operate in a limited relationship with context information. However, architectural designers have been attempting to address context through site data entry and simulations. With morphodynamic diagram-based work, a simulated 3-D environment can be created that models different types of forces, for example, attractors, repellors and gravity. Environmental factors can also be simulated, including the movement of the sun, wind patterns, temperature, topography, hydrologic action, or other site data. This design method involves environmental analysis and modeling the interaction over time through a process of adjustment. As discussed earlier, the more advanced software GENR8/Emergent Design Group is also



5.9
Jun Yu: *Forms of Cellular Aggregation* (2005)
SCI-Arc 2GBX Studio
Instructors: Marcelo Spina, Peter Testa
Software: GENR8 by Emergent Design Group/MIT

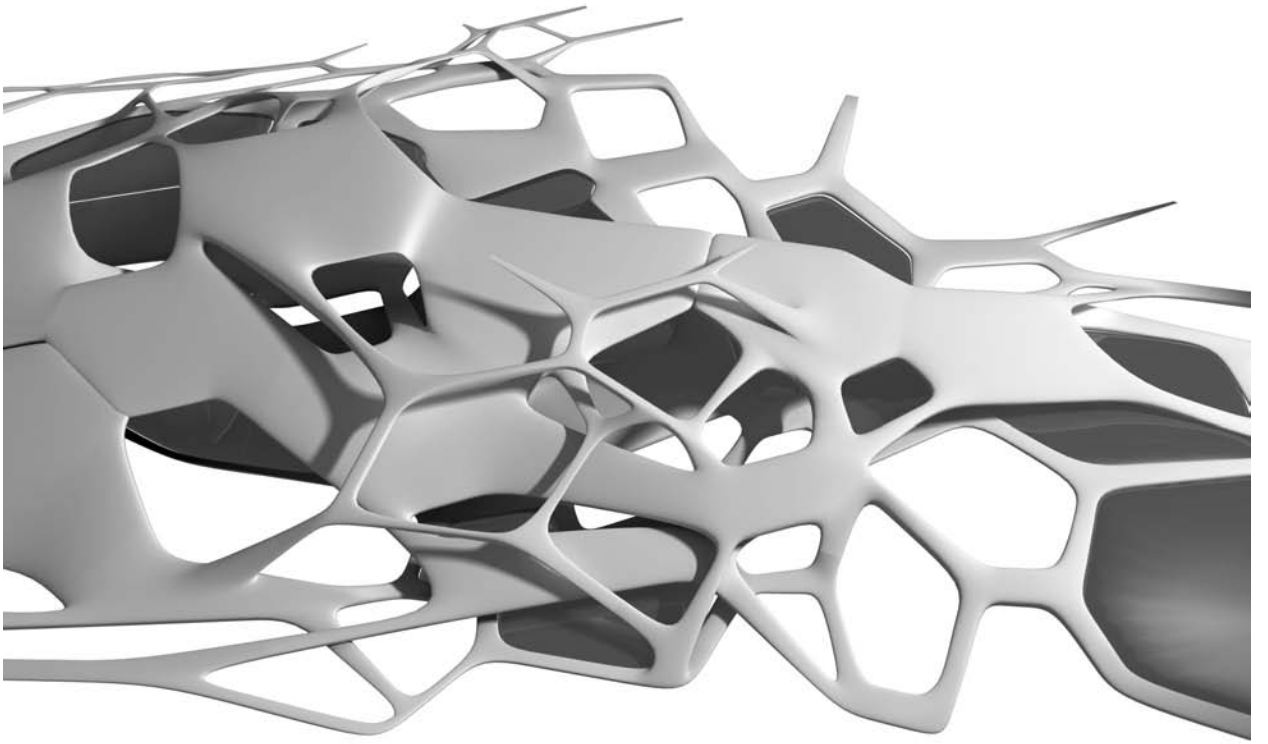
designed to integrate and respond to site or environmental information through a process of feedback. Design research is developing cross-platformed engineering software that can incorporate structural loading behavior and digital fabrication by concentrating on the interoperability of various systems and requirements.[20] Within contemporary architectural practice, SHoP Architects, New York, are known for employing industrial design and fabrication methods with their projects. They take many variables into account as part of the design system: zoning regulations, setbacks, sunlight patterns, which are placed into a data library. When the data is fed back into the model, the form alters in response, keeping its structural integrity. Greg Pasquarelli adds, "We really feel that our buildings improve as more restrictions are placed upon them."[21] With this approach, there may be many design solutions within the topology of possible solutions, each to be evaluated individually.

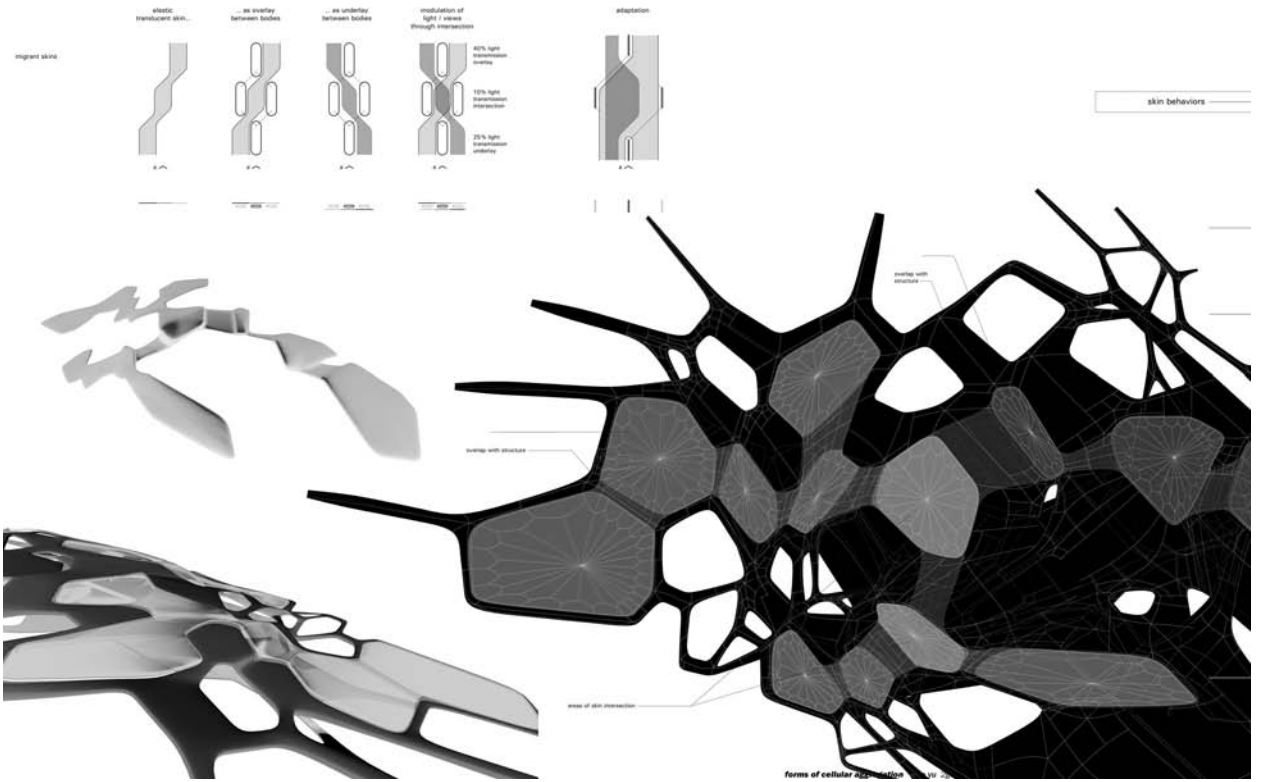
Morphogenesis

From a preliminary analysis, because most discussion of evolutionary form generation seems to be form-directed, I would like to suggest a more encompassing morphology, one that could look beyond the surface of form toward a more nuanced developmental and organizational logic. In order to then analyze digital form generation, it will be necessary, first, to investigate the processes of formation, and not just its surface effects.

An early precursor to this notion was explained by Sanford Kwinter in "The Genealogy of Models: The Hammer and the Song" (1998). He explains how Goethe was one of the early philosophers to propose formal development as a generative or computational code. Even more interestingly, he also invented the word morphology in *The Metamorphosis of Plants* (1790).[22] Kwinter then extends a notion of computational models to describe structure as organization, concluding that all phenomena exhibit formative and organizational effects. He proposes that shape- or form-producing pressures are embedded in all subsequent states of materiality. Computational code, when understood in this manner, is not simply a set of instructions, but has the potential to imply a reflexive material logic.

With regard to generative processes, during the mid-twentieth century the mathematician Alan Turing developed a theoretical model of the modern computer, the Universal Turing Machine. He also published a paper titled "The Chemical Basis of Morphogenesis."[23] In it he ventured that the computational behavior of genes could result in a morphology. By showing that patterns could be generated by simple chemical reactions, together with the process of diffusion (the Second Law of Thermodynamics), this resulted in a significant shift in perception of how the processes of development could be viewed. It also contained the first applications of computational modeling in biology.[24]

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15% light
transmission
intersection
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transmission
underlay
skin behaviors
overlap with
structure
overlap with structure
areas of skin intersection
forms of cellular agglomeration

5.10
Jun Yu: *Forms of Cellular Aggregation* (2005)
SCI-Arc 2GBX Studio
Instructors: Marcelo Spina, Peter Testa
Software: GENR8 by Emergent Design Group/MIT

Similar research in generative art has resulted in programming codes that operate within field dynamics, similar to experimental work by Hans Dehlinger, Director of the Institute "Design–Kunst–Computer" at the University of Kassel. For example, with every organized entity/ecology, there corresponds a network of forces that endow it with a general shape and program, similar to a field condition, yet creating an autopoietic relationship. Therefore every design becomes a variable composition of forces and the process of an abstract machine.[25] Such a dynamic design process takes place over time, and is neither singular nor momentary, but varying and reflexive. Inasmuch as an informatic model acts as a topology, it is also an expression of relations. The more advanced software systems attempt to incorporate this important aspect. As Testa explains:

> It is possible to look at computational methods as an open-ended exploratory process—through probing in the space of possibilities with only very general and undefined goals in mind. The goals themselves are emergent and evolve through mutualist feedback between an evolving design response and problem definition. This approach by the Emergent Design Group is intimately tied to the ability to rework, rethink and hack tools on the fly as an integral part of the process—as opposed to the idea of an ideal tool that can simply be run and results interpreted by users. EDG sought to break the subject/object split as well as the hardware/software distinction. This open-ended and multi-level strategy is demanding and not generally understood.[26]

In order to effectively grapple with the complexity of design today, designers need new methods of viewing and organizing the solution field. Computational design solutions evolve through the interplay and integration of multiple data platforms. This involves dynamically developing designs that are organized in terms of relationships, rather than just discrete objects. Furthermore, any model that attempts to conceptualize variable relationships—an informatic model, as it were—will necessitate the use of time-based media.

Fig1:Step1(初期形状)

Fig2:Step7

Fig3:Step25

Fig4:Step46

5.11
Toyo Ito architect, Sasaki Structural Consultants: Structural analysis/SAP diagram, Island City Central Opark GRIN GRIN in Fukuoka, 2005

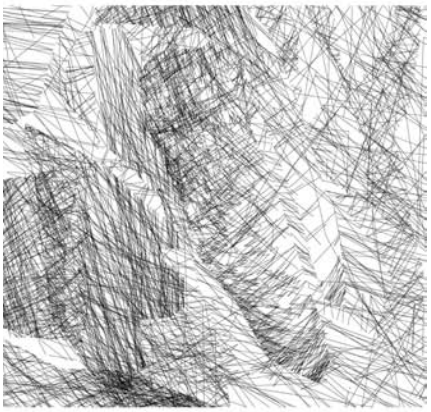
Experimental design research

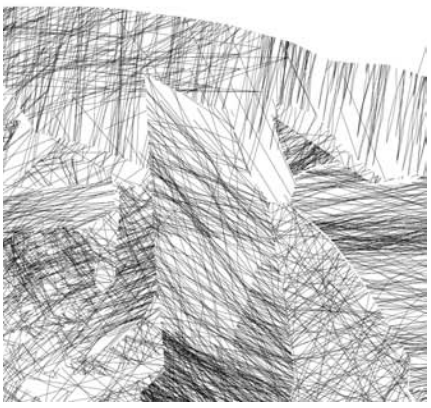
To design is to risk, to experiment. Results that are not immediately understood or applicable should not be denied their importance. The term laboratory work was used by the Russian Constructivist avant-garde to describe certain investigations that were initiated not as ends in themselves nor for any immediately functional purpose but with the notion that the investigation would eventually be deployed toward the solution of some problem. According to the United States patent office, the majority of all inventions are rarely used for their original purpose. The intention of laboratory work is simply to try out and test parameters and interrelationships so they can later be applied in the design process.[27] Furthermore, much of design research has been a bottom-up phenomenon, occurring through interdisciplinary collaborative efforts between architects, computer scientists, and media artists. The importance of interdisciplinary research (or omni-disciplinary, as Buckminster Fuller called it), cannot be overstressed, not only because of the hybridity of architecture as discipline, but also because it points the way toward a comprehensive approach to design in solving today's complex and difficult problems.

In a similar manner, the purpose of experimentation in computational design is to explore the structure and properties of different programs, the way they can be manipulated, and their formal products. The analysis herein is focused on form generation through an iterative combination of computational and subjective processes. An operational approach to architecture allows designers to subjectively observe unfolding over time, such as the growth of a plant, or the different patterns and relations that occur through inhabitation of a space. Form is then generated dynamically through the interaction of the designer, as well as the working of the algorithm.

The temporal image

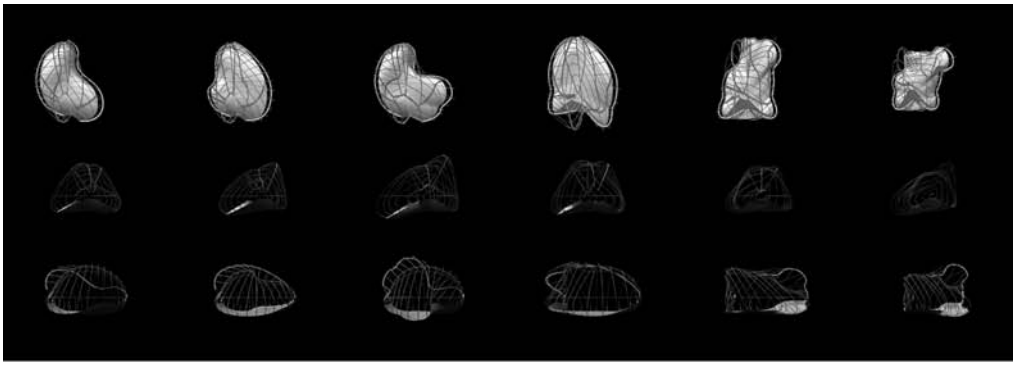
One way to approach time-based methods would be to deconstruct the terminology of form-generation, to examine the metaphors in use as a means to acquire a deeper understanding of the process. Form-generation may typically appropriate biological nomenclature related to time, growth, and movement. In actuality, all objects change over time; it simply depends on the frame or breadth of measurement one uses. In other words, every object is actually an event.[28] For example, if one were to monitor a chair (a supposedly static object) in a classroom over the course of a 24-hour day, it would seem to be animated, that is to say to have a life of its own, constantly moving and migrating as a result of the actions of its numerous occupants during the day.

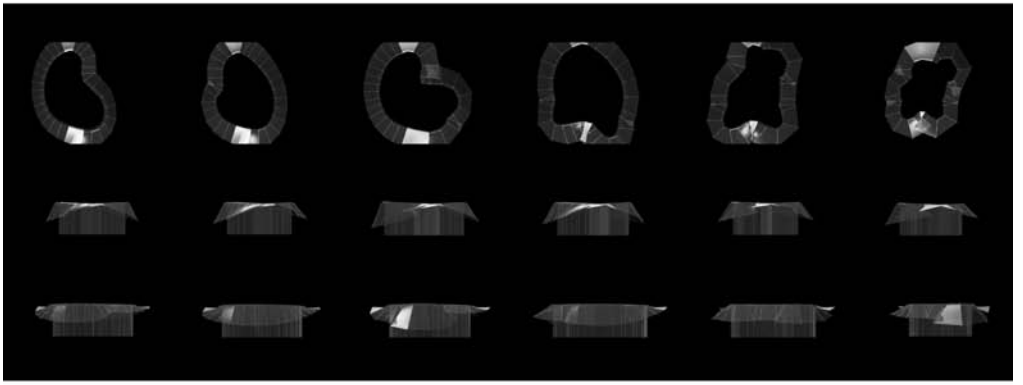


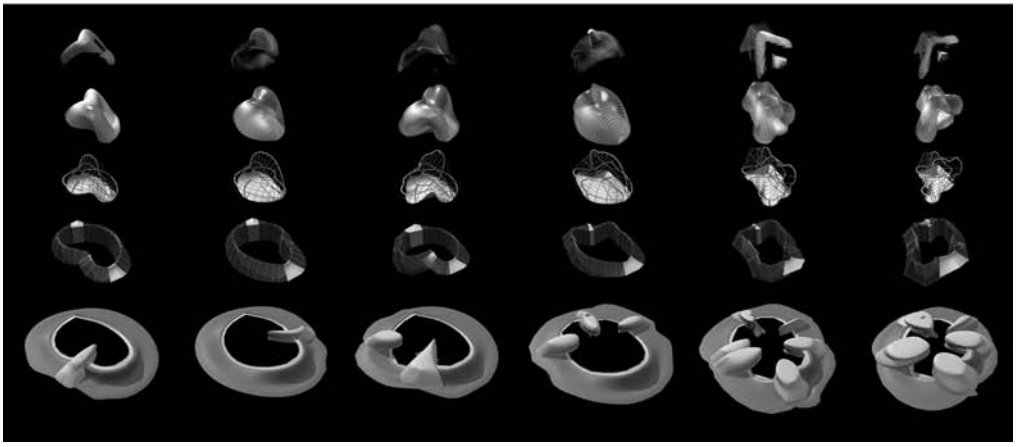


5.12
Hans Dehlinger: "B194"
generative art, 1993

Because all object/forms change over time, stasis is rare or at least is only visible in a shortened time frame. As a result, temporal theories have become instrumentalized within the computational solution field by documenting numerous and variable slices of time. The chief respect in which the architectural image has been transformed is that it now exhibits temporal characteristics, which were difficult if not impossible through previous techniques. With respect to analogue methods, the hand-drawn architectural image was inherently gestural. The more complex digitally constructed process-image is, in actuality, the residual of a set of operations. It operates as a set of instructions, not just metaphorically but quite literally, because it is underwritten in code. Evolutionary form-generating software has transformed the architectural image into event and performance, either by understanding architecture as the epigenesis of spatial conditions, or by the object being understood as the actualization of built-up potentials. Either way, the architectural image is a simulation of pressures; it is inextricably imbedded within a form-making process, as an ongoing realization, and never finished. The architectural image generated through computational methods is ontologically different not only in material, composition, and construction, but also in behavior, since it now exhibits a theory of change.







6
Formal matters

The virtual as a generative process

6.1
Greg Lynn: *Embryologic Houses* (2000)

Films, video games, Internet art, and cellular phone conversations are all virtual experiences in the quotidian sense. These frequent and familiar experiences are distinguished by a displacement of consciousness to a space apart from one's immediate physical surroundings. While it is important to recognize these phenomena, what is to be explored further is a notion of the virtual that is neither conventional nor populist, nor even a simplistic spatial or graphical illusion. Instead, I would like to suggest that architectural expression is intrinsically, though not exclusively, virtual and that this virtual terrain is the actual site of architectural production.

The concept of the virtual will be examined as a nonempirical, generative abstraction. In contrast to a photograph, an architectural concept is imageless; it does not exist prior to its representation. Instead, conceptual thought evolves in a virtually formed, unfixed state and actualizes within expressive media. By this I do not mean to say that the virtual exists outside material expression. On the contrary, the virtual is embedded within the actual, interpenetrating the same space and time. Just as a cellular-phone conversation is experienced both phenomenally and subjectively, so too the design process is experienced on multiple registers within a variable system of internal and external relationships.

An investigation into the epistemology of virtuality reveals an extensive theoretical history. This intellectual history suggests that the virtual has always existed as a *conceptual tendency towards expression*. Anti-realist philosopher Giovanna Borradori concurs in her view that the virtual is a *constitutive condition* of human experience.[1] In this way, the virtual operates *in* the media of expression, not *through* those media. This definition of the virtual is vital to understanding the operative role that it plays in the design process and will therefore be discussed in terms of cognitive concept construction and performatives. It is also important to note that, in the following definition, virtuality does not exist in

6.2
Bernard Cache and Patrick Beauce: CNC milled partition (1998)
The Paris-based design/architecture studio *Objectile* developed their own software, which enables the design and production of curved and variable shapes using numerically controlled machines; thus singular objects can be mass-produced.

isolation, but rather within relations; nor is it determined by conventional representations of cause and effect. These qualifications tend to verge or intersect at a fundamental question related to time: if the virtual is constituent, relational, and noncausal, how does change or emergence occur?

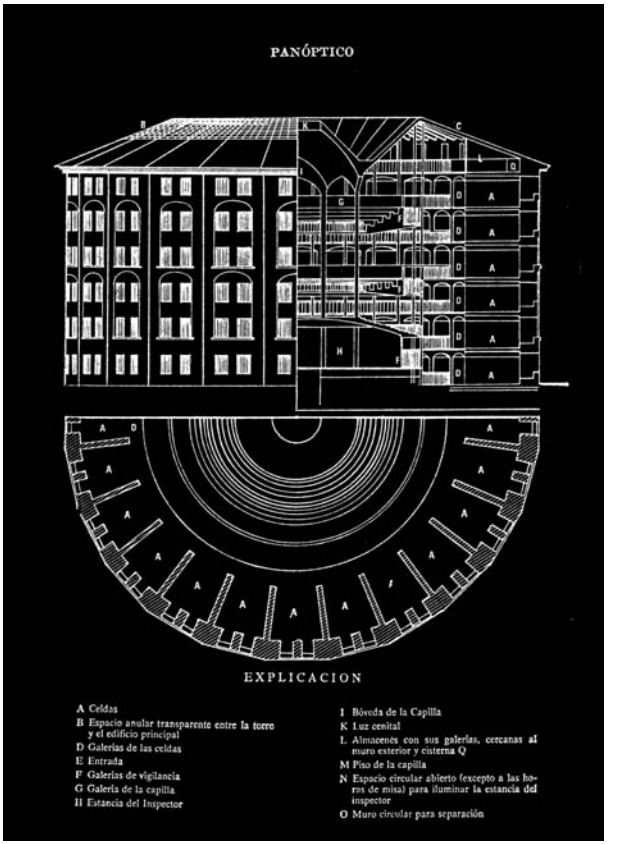
Although imageless, the virtual is productive

Psychological studies on narrative and dream formation have consistently shown that all humans construct concepts, this being an inherent and not an acquired characteristic.[2] Therefore, a purely empiricist point of view simply cannot suffice to explain divergent thinking. The virtual, as a nonempirical conceptual tendency, is an intrinsic feature influencing both the architectural design process and the production of new architectural forms. The virtual could be said to consist of a series of nonlinear cognitive resonances involving abstraction and transformation. Furthermore, virtuality as a generative abstraction has force. For example, an architectural proposal can affect social relations via the power of imagination. As Foucault explained in regard to the panopticon, a structure need not be built in order to influence human behavior.[3] In that sense, although nonvisible and immaterial, virtuality is real and with affect.

Because the virtual has affect, it cannot be understood in isolation, but only within a dynamic field of relations. This notion has a relatively recent history, which is in contrast to conventional notions of time and space. Historically, Newtonian physics manifested as a restricted way of thinking about spatial conditions. During the Renaissance, a rationalized system of representation known as Cartesian perspective was used as a method to quantify space. A mathematical grid was laid out and any object was fixed by horizontal or vertical coordinates on that grid. As Sanford Kwinter explains in "Emergence: or the Artificial Life of Space," this method is said to have divided time from space.[4] Space was then viewed as a neutral, static background, similar to a stage set, where isolated figures were variously positioned. This method reconceptualized space from fluid to static, infinite to finite, not unlike the way Taylor's much later time and motion studies quantified time, motion and activity in his *The Principles of Scientific Management* (1911).[5]

As Kwinter goes on to describe it, in a Cartesian matrix each object was extracted from a flow of time/movement/space and was determined or quantified by its numerical spatial coordinates. "Space was no longer the varied and innumerable manifold of evolving phenomena, objects, and events, but instead an abstract grid whose purpose was simply to *measure.*"[6] Its primary characteristic was to fix as fundamentally homogeneous and distinct that which by nature is continuously different. Time was brought in line too, as form,

6.3
Jeremy Bentham, architect: Panoptican system prison design (1791)
Courtesy of the Bancroft Library, University of California, Berkeley



of necessity, became a *pre-existing* object. It was inconceivable that forms could emerge and evolve as part of their environment; instead, they had to exist in a preobjectified state.[7]

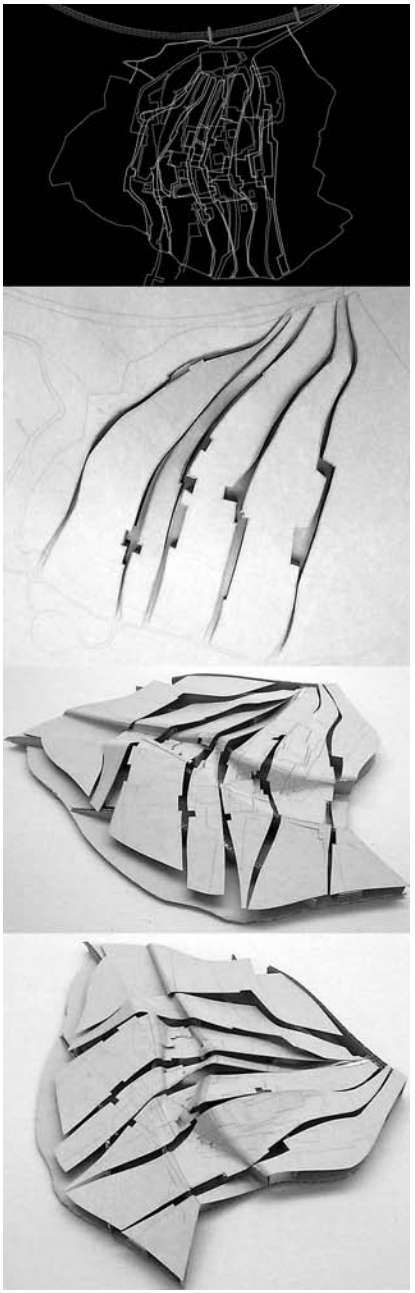
The pre-Renaissance view of phenomena as varied, complex, and rich became gradually quantified into discrete, linear, and sequential. Furthermore, Cartesian perspective and Newtonian physics, as representational models, became psychologically internalized as perceptual modes of organizing phenomena, thereby shaping the cognitive perception of spatial and causal relations. How can we re-imagine this post-Enlightenment notion of space/time?

While Einstein's theories of relativity in 1923 led the way to a more indeterminate version of space, on a more pragmatic level, the mid–twentieth-century theories developed by Norbert Weiner in cybernetics (1948), as well as systems theories, provided more intricate ways to imagine spatial relations. There has been a renewed interest in complex cybernetic systems where one movement influences the rest in a process of adjustment. Drawing from Maturana and Varella's research, Brian Massumi's radical empiricism (2002) entailed a new understanding of biological systems linking together a single integrated organism within a type of fluid matrix or field operating interactively, with neutral space no longer forming a passive substratum.[8]

What Massumi is suggesting dovetails with new cognitive models derived from neurobiology. Not only can we come to understand spatial relations in a more reflexive way, but a complex understanding of space can lead to other models of causality. Today's informational architecture does not reproduce or represent an idealized Platonic form, nor does it oppose idea to matter, but acts as an emergent tendency. In other words, architectural design is not simply object-based, but also context-dependent, operating as material intelligence within a relational field dynamic. "The field, however, does not preexist, but is always present as a virtuality. Determined within and by the plastic events that articulate it and render it actual."[9] Therefore, one could argue that what is most intrinsic to architecture is always present, but exists as a potential of the design. While the virtual idea is its own contextual reality, the interactive process of design results in the production of new realities.

Consider, for example, the figure/ground topologies of Peter Eisenman's proposal for the City of Culture of Galicia, Santiago de Compostela, Spain (2002–2006), which is generated from a layering of the ancient medieval street plan over the topographical contours of

6.4
Peter Eisenman/Eisenman Architects: Site plan and study models (2002)
City of Culture of Galicia, Santiago de Compostela, Spain



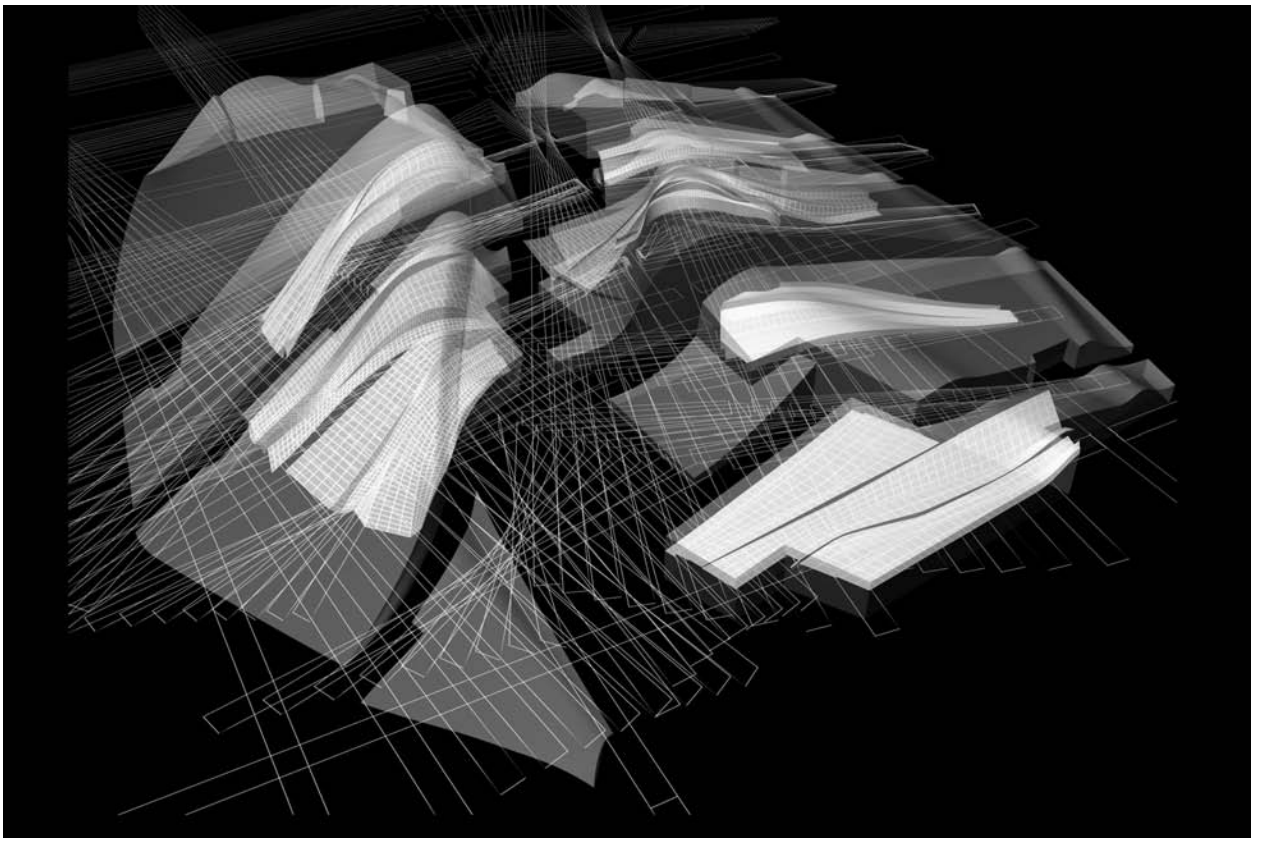
the site. The virtual memory of the medieval city interacts with the present-day topography. The intersections between the virtual and the actual become new places of interaction within the museum, an expressive merging of time and space. His diagrams purposefully distance themselves from any previously defined architectural interiority. Instead, Eisenman attempts to express multiple temporalities by mapping the relations *outside* of time, as traced through his other projects, for example, the Long Beach Art Museum and Frankfurt Rebstockpark.

However, a different design methodology is at work with dynamic simulations. In design studies for the Leisure Center for the 2004 Olympic Games, Athens, Greece (2002–2003), Ali Rahim and Hina Jamelle of Contemporary Architecture Practice constructed a dynamical systems model where the site-generated data is rigorously structured on a relational basis.

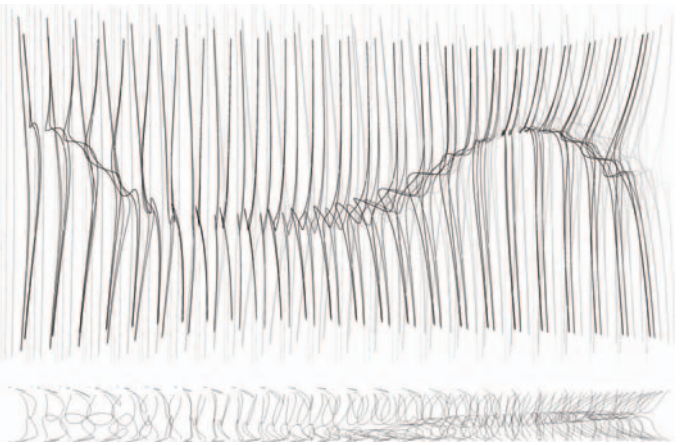
Reflexivity develops between internal programmatic pressures and external site-related pressures, creating an animation of forces by means of a communicative process of action-based relationships. When activated by pressures, each particle interacts with adjacent particles, generating affects within the system. Over time and with numerous iterations integrating informational feedback, accumulated patterns emerge.

If the design space or solution field is interactive as well as performative, then it is really an energy-event space. Kwinter suggests that the traditional causal relationship represented in mid-century thinking by a problem–function–solution model has been succeeded by an information–field–interaction model.[10] In this manner, the notion of the virtual as a field of dynamic effects has spanned numerous disciplines: art, philosophy, and linguistics. The literature synthesizes findings related to relativity, subjectivity (points of view), and, most importantly, translations of virtual to actual related to emergence. Proceeding from a definition of the virtual as a continuum of actuality, which is to say productive, this proposed model, in contrast to earlier models, is clearly not representational, but instead is capable of propagating new realities.

The design process is relative and subjective, dynamic and interactive. Transformations figure prominently in emergent digital processes. Similarly, developments in computational modeling and simulations in the sciences have contributed towards a shift in the study of contents with the analysis of relations. These disciplines suggest that the virtual field of interaction is best described as multidimensional generative space. It is a relational continuum capable of creating spatiality.[11] A more accurate description of the virtual,

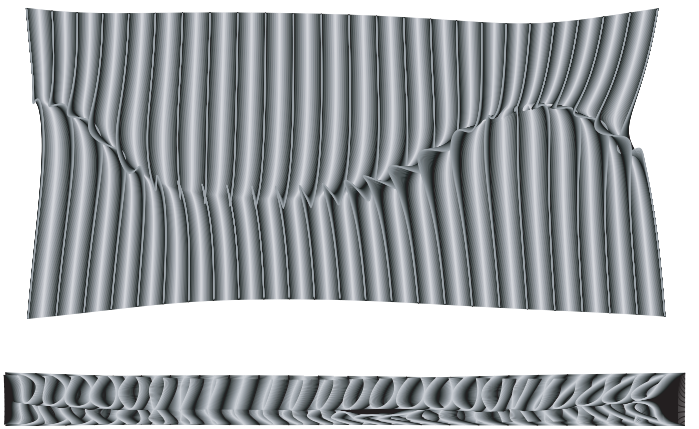


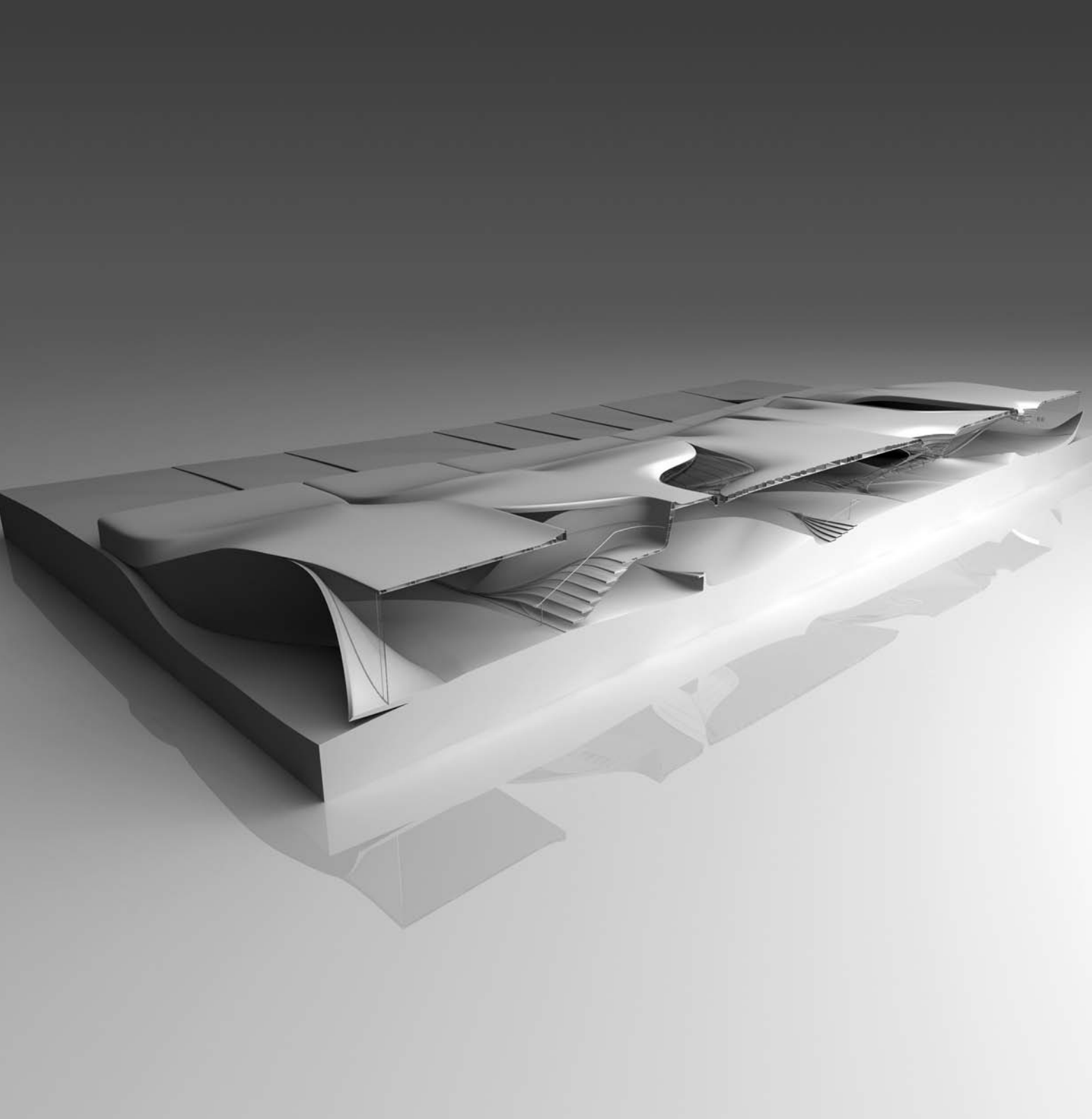
6.5
Peter Eisenman/Eisenman Architects: Deformation diagram identifying interior volumes within the building (2002)
Cultural Center of Galicia, Santiago de Compostela, Spain



6.6
Ali Rahim and Hina Jamelle of Contemporary Architecture Practice: *Trajectory:* Leisure Center for the 2004 Olympic Games, Athens, Greece (2002–2003)

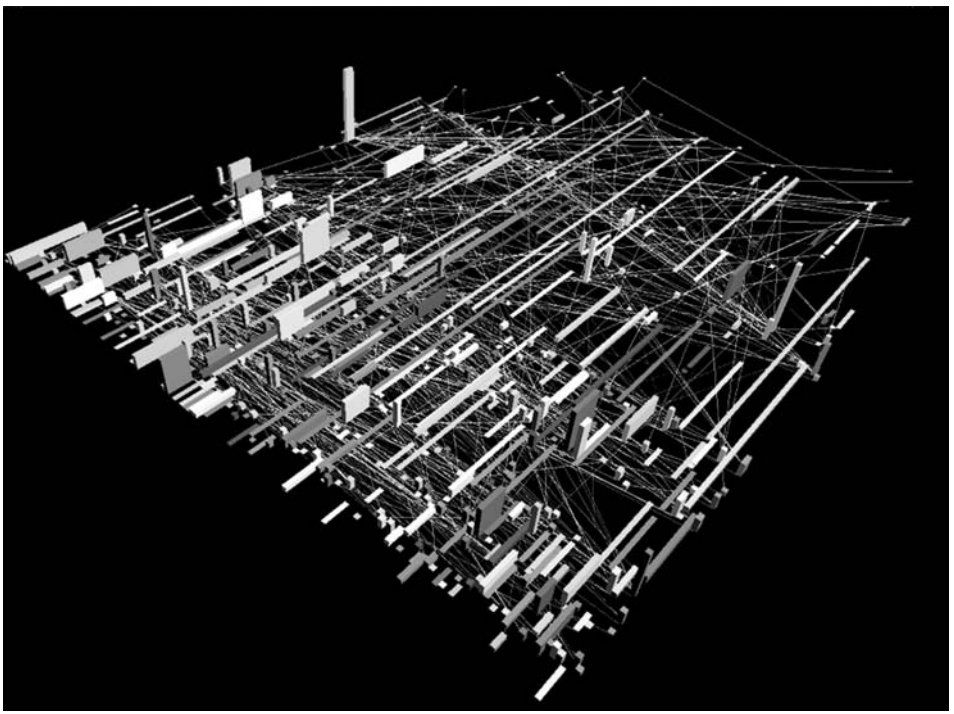
6.7
Ali Rahim and Hina Jamelle of Contemporary Architecture Practice: *Surface Inflection:* Leisure Center for the 2004 Olympic Games, Athens, Greece (2002–2003)





6.8
Ali Rahim and Hina Jamelle of Contemporary Architecture Practice: *Sectional model:* Leisure Center for the 2004 Olympic Games, Athens, Greece (2002–2003)

6.9
Fabio Gramazio and Urs Hirschberg, designers: ETH Zurich (2001)
Phase [X] is an open source evolutionary system; out.world applet of Phase [X] phases describes ordering by various attributes.



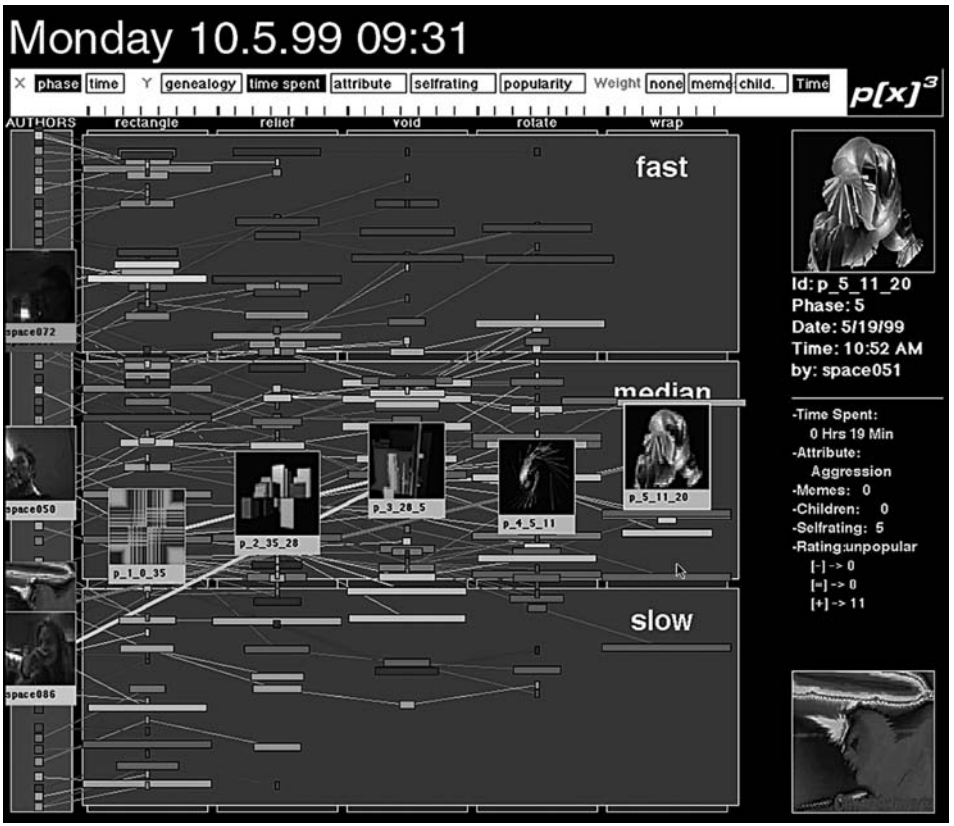
then, is as the nexus of an entire set of cognitive, social, and material activities. Seen from this point of view, design acts are not just the predictable formalization of thought into spatiality, but a modal continuum of expression loaded with potentiality.[12]

Temporality

In a further explication of field dynamics, is it necessary to recontextualize not only space but also time, in order to deconstruct the myth of causality and understand emergent forces. First, there must be a distinction between the concept of time and the experience of time. Historically, timekeeping originated with tracing natural phenomena and this was later followed by mechanical devices that measured time. Timekeeping became further rationalized through eighteenth-century maritime navigational practices. Measured time was symbolically represented as similar, linear units, and so eventually clock time came to cognitively represent time itself.[13] In contrast, actual life is experienced not as a succession of demarcated conscious states that progress along an imaginary line, but instead as a continuous flow. Although scientists may observe and record objects and events in succession, time is presented to consciousness as *duration*, an endlessly flowing process. "Real time" is experienced as duration and apprehended by intuition, not through separate operations of instinct and intellect.[14]

The virtual idea, as it were, is simultaneously present in the object as well as existing in abstraction, being an interweaving of substance. Bergson said that the act of perceiving brings forward memories by drawing the past into the present through association.[15] These same memories project into the future as well, when subjective experiences shape perceptual understanding through their prior coding of experience. Indeed, the virtual field is not a *tabula rasa*. There is instead a context-laden substrate that has been termed the background and operates as a set of social and biological capacities through which information is translated.[16] Ultimately, the background is a set of nonrepresentational mental capacities that enable new realities to form. Memory is an operative factor; these observer-relative, culturally constructed memories manifest as pressures by shaping the perceptive potential of phenomena. Similarly, Henri Bergson proposed memory to be a virtual image that coexists with the perception of the object. Critically, according to Bergson, the virtual is not to be confused with the possible. The possible is always constructed after the fact; it is irrevocably tied to what is already known, and thus it cannot be new and as such is opposed to the virtual. Referring to his recognition of the virtual as divergence, he argued that divergent thought displays a willingness to jump beyond obvious solutions by avoiding conservative rational logic that arrives at predictable solutions.[17]

6.10
Urs Hirschberg, designer:
ETH Zurich (2001)
3-D network of out.world
applet of Phase [X]2:VRML
representations of the data-
base.



This intrinsic view differs from the distinctions set out much earlier in Classical philosophy. Plato described the virtual and the actual as being cause and effect, or separate and discrete. He stated that the ideal form exists independent of physical reality. This ideal is known only through cognition, and it is through physical efforts that attempts are made to bring it into actuality. Plato believed that the object of thought was something artists or designers should then strive to recreate in its perfection.[18]

Compare this with Walter Benjamin's writing in "On Language as Such and on the Language of Man", where he posits that the virtual is related to self-definition and identity, to modeling, to roles, or to subjecthood. How are Benjamin's roles different from Plato's ideals? Benjamin's roles are *internalized*, not like Plato's ideal forms, not a duality. They are neither different ontologically, nor are they two different domains of being, such as an architectural idea here and a debased formal expression there. As identity and expression, virtuality is *in* the language, not *through* the language.[19] Virtuality is in the medium, not through the medium; in the structure, not through or separate from the structure.

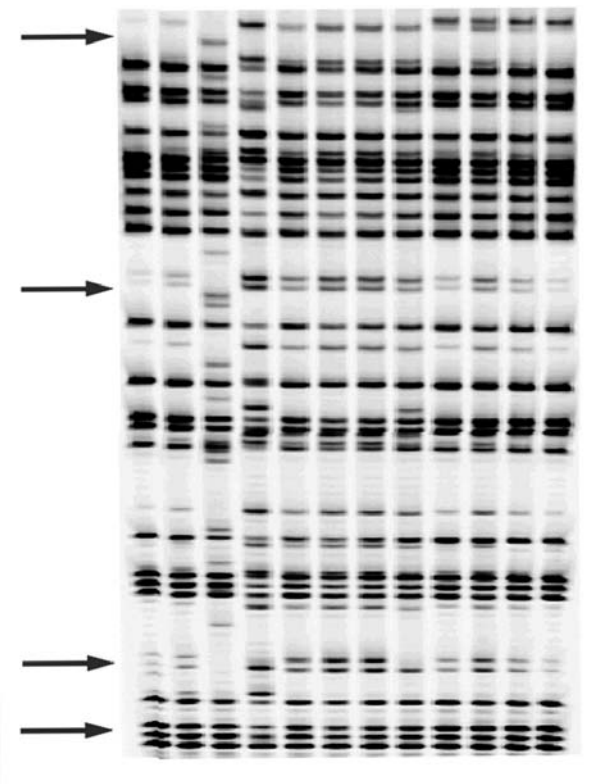
Because the virtual, in contrast to the possible—which is to say the predictable—already possesses a certain reality in itself, it does not need to be realized (any more than a film must be acted out in the real world). This relation to the actual is radically different from the relation of the possible to the real. The former rests on similitude and consistency, the latter upon alteration and differentiation. Whereas the possible is therefore expected to realize itself causally, the virtual becomes actual but only by altering itself. Actualization or differentiation in this sense is continually inventive.

Material intelligence

How does change occur? Is actualization the same as emergence? A proposed model of the virtual might consist of a context-laden substrate that operates as a set of social and biological capacities through which information is translated or interpreted. As such, the informational interface is provisional and contingent. Does such a model as described already exist? It may prove useful to look for principles of actualization in the biological sciences, within genetic processes.

It was first imagined that generative laws were stable constraints, which could repeatedly reproduce similar form.[20] Yet at the same time, genetic theory had also to contend with a conflicting observation that information transfer was not without individuation. Through phylogenesis, the genetic model represented a new type of ontogeny, which constituted

6.11
DNA mutation: A slippage in the code
Scan of human mtDNA.



the only means available to innovate in this way. In other words, with a genetics model, change occurred through mutation expressed in the genetic code. In this case, mutation can be defined as any variation occurring in the instructions that a gene carries.

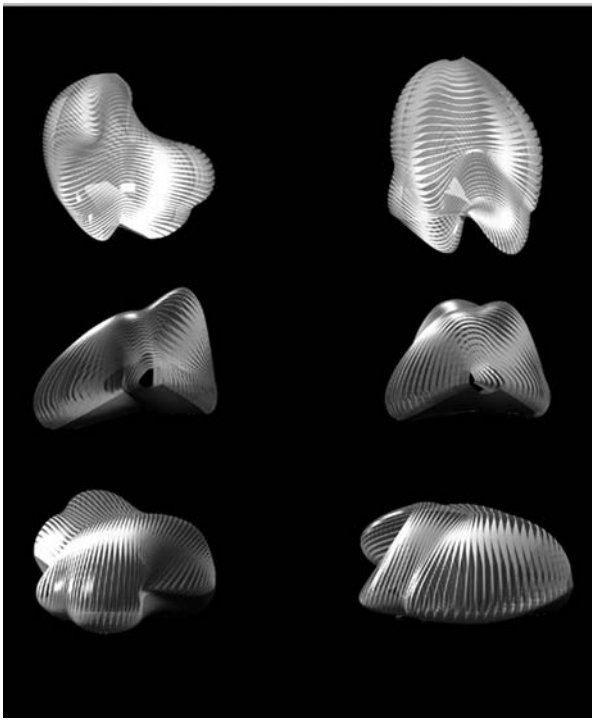
Mutations mainly arise as *copy errors* when DNA is replicated at mitosis and meiosis. Therefore, each gene is never fully fixed, specified, or precise in form. A gene's influences are mediated by its interaction with other chemicals and genes; every point in the system responds with acute sensitivity to any change or event anywhere else in the system. No action in a single gene can fail to affect, or be regulated by, all the other genes in the overall functional complex. Again, the principles of an epigenetic ecology are expressive of a field dynamic. Darwinian evolution requires a constant supply of variation: much of it is supplied by mutation, which could be called an interpretation caused by translation. Change occurs at the molecular level, driven by genetic drift rather than natural selection, which means that randomness or unpredictability is continual and necessary for survival. In this way, a mutation-selection balance can maintain a genetic polymorphism.[21]

If the genetic model of mutation is extended theoretically, one could venture that formal expressions are a shift in the virtual. Accordingly, variation must be linked to the virtual. Samuel Weber writes, "the nature of the virtual is so constructed that actualization signifies differentiation for it."[22] That is to say, similarly to genetic coding, differentiation is embedded within material intelligence. This leads one to agree with Deleuze that the virtual is veritably creative: "To think is to create. There is no other creation."[23] Intellectual thought, innovation and design all actualize through differentiation; they are all examples of divergent thinking.[24] Yet these examples can only be viewed as divergent when seen through the lens of time. Within the concept of structure must then be embedded a temporal characteristic, one that could incorporate variation, developmental growth, and actualization over time, and that is neither static nor directional. In addition, within our conceptual model of the virtual, a potential for unpredictable randomness would also have to exist.

The interface as actualization

The history of the virtual as a conceptual tendency has relied upon successive models of actualization. Many prior inaccuracies were due in part to an outmoded reliance on reductive notions of space/time, cause and effect, and historical formalism. Within scientific circles, it is commonly known that if a system is closed, the results will be predictable, not novel. However, twentieth-century theories, most notably relativity and complexity theory, have supplanted the linear, sequential model with a more complex, dynamic, and

6.12
Greg Lynn: *Embryologic Houses* (2000)



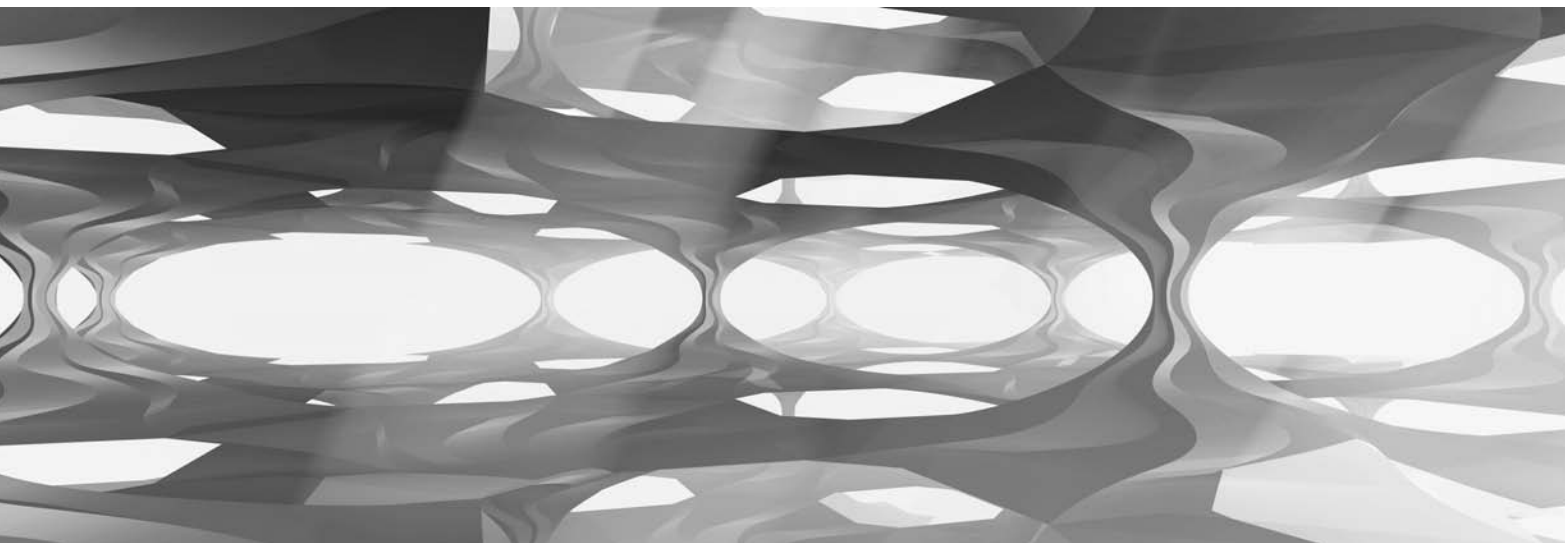
variably weighted topological model. Drawing from field dynamics and the biological sciences, these more nuanced models allow for a certain amount of indeterminacy, which can lead to greater potential for divergence.

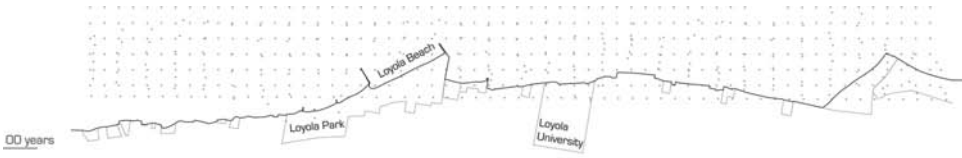
Virtuality's very lack of differentiation or concreteness is advantageous because it allows for permutations between various modes of thought or expression. Copy errors through translation result in unexpected combinations. Design acts are neither linear, nor predictable in cause and effect. In addition to rational processes, they also seem to incorporate intersubjective intuition. Studies have shown that designers work in parallel with the goal state, often without conscious awareness. Psychologists refer to this phenomenon as accessing primary material, that is to say material unprocessed by the rational mind.[25] Chance operations or nonlogical connections may occur.[26] This complexity of relations and resonances results in the production of new modal realities. Seen in this light, design acts are not just a simple case of causal formalization, but operate as a divergent network of forces.

Virtuality within the design process appears to be an open relational system. It is constitutive of form, but not limited to form; instead, it is defined operationally. Conventional notions of causal time cannot bind it. The virtual actualizes through an iterative, interactive emergent process. It is neither purely technique-driven nor concept-driven. Instead, it is the interaction, the translation between the two drivers where new insights occur. The gap between the subjectivity of the designer and the systematic methods allows new solutions to emerge.

6.13
Embryo development and germination: *ABA controlled expression of embryospecific genes during wheat grain development* (1983)

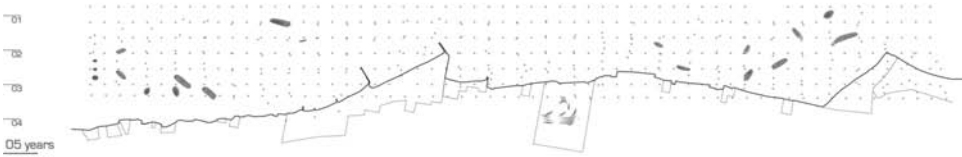
6.14
Haresh Lalvani, concept and design: *WaveSpace Labyrinth* (2001, 2004)





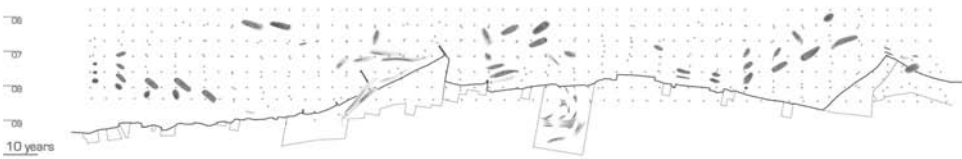
00 years

THE FIELD
The field consists of the shoreline with existing public spaces and an imposed grid of growth centers with a potential directionality. Growth direction depends on economic development and neighboring relations of public and private.



01 02 03 04 05 years

0-5 YEARS
Private growth begins with the development of isolated atolls just offshore of existing residential zones. Public growth begins at Loyola University with the reconfiguration of its central court.



06 07 08 09 10 years

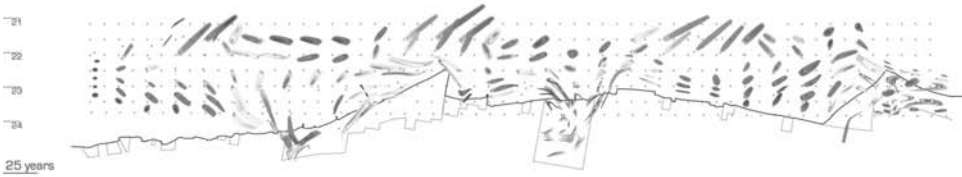
5-10 YEARS
As private growth continues some atolls are developed for rental and leasing possibilities. Semi-public connections are made between Loyola Beach and Loyola Park. Loyola University begins to expand in both directions. Ardmore Park is activated by a Pier-like atoll connecting shoreline and waterfront.

11 12 13 14 15 years

10-15 YEARS
Relation proximities force the implementation of sensitive zoning considerertions. Economic development shifts growth patterns.

16 17 18 19 20 years

15-20 YEARS
The city's edge begins to delineate. Atolls in close proximity to Loyola and Park create more beach front space and establishes a new kind of experience. The univerity extends into the lake connecting to semi-private atolls for student/faculty housing.



21 22 23 24 25 years

20-25 YEARS
The clustering of public atolls generates connected surface area for large scale public events.

26 27 27 29 30 years

25+ YEARS
Out of a full field emerges a new lifestyle with fluid integration between city edge and waterfront.

7
The status of the architectural image

7.1
Ramiro Diazgranados and Georgina Huljich: *Infinity Edge: Park for the 21st century* (2004).

Our perception is that body of images whose variable horizon expresses our potential for action.
Bernard Cache[1]

The integration of digital technologies into architectural design methods has resulted in changes beyond the immediate and pragmatic concerns regarding modes of production. As a first step towards realizing the theoretical implications of such a transformation, the architectural image's ontology was reexamined historically. This reexamination was found to be productive in that it encouraged a critique of origins, specifically various received notions from Classical, Renaissance, and Modernist thought, all of which have previously formed the foundation and definition of the architectural image. It was also discovered that these earlier defining philosophies and methods, whether idealized geometries or Cartesian notions of dualistic space/time, or even progressive Modernist attitudes toward functional use-objects, no longer seemed to provide a stable frame or cohesiveness for understanding the forces operating on the architectural image today.

This sense of shifting of historical foundations is further accentuated by the fact that the contemporary visual arts—which include architecture, sculpture, performance, media installations, graphic design, film, and the Internet—have pluralized and hybridized their once-separate disciplines. However, as we have seen, the demise of the pure, immutable art or architectural object began much earlier, during experiments in conceptual art during the 1960s and 1970s. These movements of the 1960s attempted a redefinition of the medium into an expanded field. Even so, the loss of conventional disciplinary boundaries has resulted in consternation within the academy. However, as a response, many historians and theorists are attempting to address this issue.

The establishment of multidisciplinary fields of research such as visual studies is one response. It has been noted previously that visuality is all-encompassing as *Weltanschauung* and as a theory of reality, and yet it can be as precisely defined as the "practices of seeing the world."[2] Historically, architectural pedagogy has played a constitutive role in the construction and implementation of viewing regimes and the social construction of vision. Today, with the advancing primacy of vision and the effects of a global market-based economy, new methods of communication and design continue to destabilize architecture, yet at the same time offer new means of expression.

By drawing on philosophy and design theory and methods, as well as a history of art and architecture, the status of the architectural image has been examined from the standpoint of an inner logic of the design process that underlies all architectural expression. The architectural image is exceedingly important as it communicates a mode of thinking.

Philosophically, visuality is the symbolic form of the visual experience.[3] The image, however, was found to be a slippery signifier. An ethnography of the architectural image has shifted its focus over time from the idealized representation to the indexical trace, to now the computational model endowed with generative capacities. In addition, architectural designers also employ perceptual/cognitive entities: imagined mental models, memes, or engrams.[4] Examination of theoretical mental models creates speculation that the creative process may be linked to particular configurations in the brain that could be understood through both digital and biological frameworks.

While interdisciplinary in method, this investigation is actually an exercise in restraint or omission in that any analysis of architecture through one sense only, in this case vision, foregrounds characteristics that are typically backgrounded *vis-à-vis* other building issues. Yet focusing on one particular aspectual investigation of architecture shows that a redefinition of the architectural image based on difference is necessary. In the terms of Derrida's theory of the supplement, choosing visuality over, say, mass means presencing architecture's absence. (The absent mass is still present, as A always bears the trace of B.) Similar to media, it bears the trace of both the concept and the expression. When the visual is present, mass, though absent, is also present through the action of the supplement. Mass's presencing is experienced as memory in a virtual sense, since both knowledge and memory are acquired through corporeal enaction (Chapter 5).

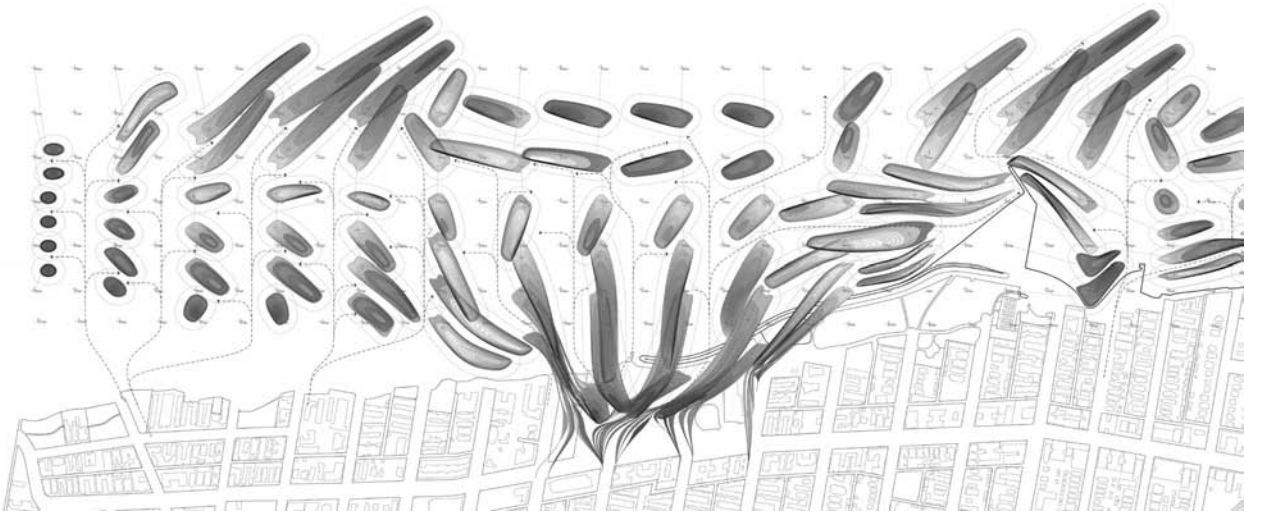
Like Derrida and Deleuze, Jean-Luc Nancy employed spatial analogies in his discourse as a means to visualize relational concepts:[5] Nancy's responsive or interactive zone of touch

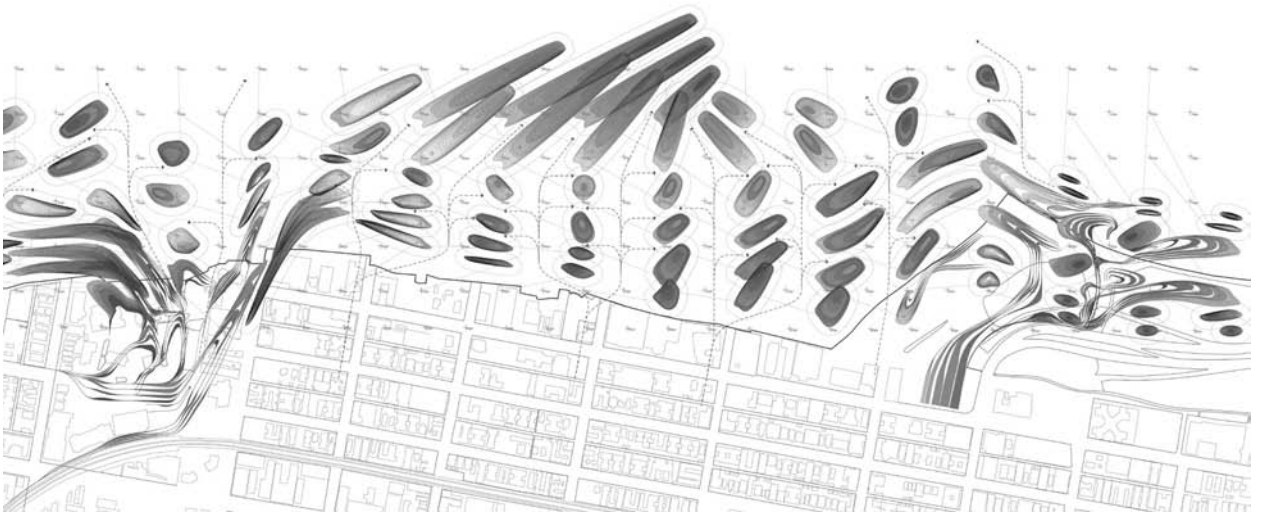
acts as a trope for the senses while at the same time attempting to avoid empiricism.[6] While architectural theorists may say that visual studies cannot address architecture's inherent materiality, I would like to propose that vision *is* located on the margins of this zone of touch, which also borders materiality. I suggest that seeing *is* tactile: a visual sense of touch is one way to consider the materiality of electrons. Furthermore, vision is precisely the first way in which we first engage buildings. Whether or not from Benjamin's elaboration on selecting the frame, vision *is* the initial sense of interactivity with architecture. This is certainly not to deny textural materiality, audio sensations, and soon. However, as postcolonial theory has made clear, it is not only valid but instrumental to consider the necessity of the subordinate part of the equation. Through the adoption of a research method based on the subordinate, it is possible to isolate and juxtapose different elements, that is to say to deterritorialize the architectural image, with the result that relationships of interdependency are made clearer.

While the advent of digital methods caused many practitioners to conclude prematurely that digital methods are just a tool, research has shown that tool use is iterative and has social consequences. The panopticon did not need to be built to affect human behavior. Therefore, an important part of this investigation is to consider the differentiation of differences. The architectural image, as used in design explorations, is not simply descriptive; it is constructed, albeit in an abstract or immaterial world. An analysis of the architectural image demonstrates that it is different not just in terms of its media specificity, that is to say constitutionally, but also operationally. The process is now constituent to the image. It may even be argued that the architectural image today *is* the code, that is to say, it is a screen shot of the actual program. What is crucial is that the architectural discipline can learn much from the investigations made by conceptual art movements of the late 1960s, which attempted to decontextualize the existing cultural codes and speculate on the ontological basis of art. Their radical explorations led to the conclusion that art (and, I would like to add, architectural design) is conceptually generative and without need for objectification.

Additionally, digital methods have augmented real or actual experience with conceptual worlds. The architectural image now operates in a dynamic space; it is endless, never finished. The architectural image can always be altered, translated, exported into other forms of digital media. This method is active and dynamic rather than static. Moreover, taking into account time/motion and animation, digital research is not solely based on form generation, but includes relational generation, and anti-form or *informe,* to borrow Bataille's term.[7] Nor is the transformation of the architectural image merely concerned

7.2
Ramiro Diazgranados and Georgina Huljich: *Infinity Edge: Park for the 21st century* (detail) (2004)





```
//////////GENERATOR CODE

int $totalRenders= 60;                                          //number of skyscrapers to generate

setAttr perspShape.farClipPlane 3000;                           //expand camera's clipping plane
chdir "C:/skyscraper";                                          //location of data on disk
$fileId= fopen ("skyscraperData.txt") "w";

//////////OPEN RENDERLOOP
for($render=1; $render<=$totalRenders; $render++){

//////////PARAMETRIC RANGES
int $helix= rand(4,8);
int $bendPoint= rand(20,46);
float $bendIn= rand(-7,-1);
float $bendOut= rand(1,7);
float $rotationIncrement= rand(1,80);
float $groundSize= rand(20,95);
float $structureOffset= rand(5,45);
float $structureDepth= rand(-80,-20);
float $peak = rand(2,45);

//////////EXPORT DATA
chdir "C:/skyscraper";
$fileId= fopen ("skyscraperData.txt") "a";                      //create or open .txt file

fprint $fileId(
"BUILD "+$render+"\n"+
"total helixes      "+$helix+"\n"+
"bend at floor      "+$bendPoint+"\n"+
"bend in slope      "+$bendIn+"\n"+
"bend out slope     "+$bendOut+"\n"+
"rotate rooms by    "+$rotationIncrement+"\n"+
"offset structure   "+$structureOffset+"\n"+
"depth of pylon     "+$structureDepth+"\n"+
"height of room     "+$peak+"\n \n");

fclose $fileId;

//////////CREATE TOWER
float $x; float $y; float $z;

for($circCurve=1; $circCurve<=$helix; $circCurve++){  //create 3 circulation curves
        curve -d 3 -p 0 0 0 -name ("circ"+$circCurve);
        $z = 1.;                                                //reset variable $z
        for($i=1; $i<=50; $i++){                                //open curve points loop
                if($i<$bendPoint) $zAdd = $bendIn;              //lower stories bend in
                else $zAdd = $bendOut;                          //upper stories bend out

                $y = $i*10;                                     //height to space stories
                $z += $zAdd;

                curve -a -p 0 $y $z ("circ"+$circCurve);        //add curve points
```

7.3
Joshua Dannenberg and Chris Schusta: Partial code from *Metacity Lagos-Loop* (2006)

with its two-dimensional representation; rather, if architects were formerly deploying images, they have now evolved into organisms through the extension of design methods into three-dimensional modeling, generative software, animation and intestive installations.

Computational studies concluded in the 1970s that designers need to work in risk-free environments. Contrary to Baudrillard's writings,[8] simulations are necessary to extend the imagination and to test ideas.[9] However, the traditional relationship "function–form–structure" has now been succeeded by "information–field–interaction."[10]

No longer can architectural expression consist of a purely isolated object. Visuality is one method of examining the architectural image as not simply an object solely in the actual world, but rather as a methodological assumption, one analytical point in an ongoing investigation: scientific, historical, critical, ethical, and political. It is an investigative process of human seeing, picturing, and imagining.

Therefore, it can be seen that design methods, and their attendant imaging techniques, must continually address a level of social and pragmatic complexity generated by a postindustrial global economy. Images themselves are never neutral; they are socially constructed and performative in operation, that is to say these constructions have ramifications. The adoption of digital design methods has resulted in a verifiable transformation of the architectural image, in addition to the potential social and theoretical transformations that continue to impact architectural design practice and pedagogy today.

It seems we are left asking more questions than we started with. However, this questioning is fertile in that it continually engenders a critique. Therefore, the objective here is to explore the possibility of a more inclusive definition of architectural expression, where we can relocate the site of architectural design to a conceptual activity situated within a design continuum, a system of immateriality/materiality that already exists operationally in the physical sciences. Digital methods express one phase on this continuum: a substantive transformation that occurs conceptually through a trajectory of thought, thereby recasting the architectural image discourse, from one based simply on representational methods and modes, into a description of more open-ended and generative design processes.

Architecture, similarly to art or other forms of cultural production, is at once immaterial and material. "It is the duty of art to put an end to art," states Jean-Luc Nancy.[11] I pose the question, then: does a new medium put an end to architecture or art? The answer must be no; a new medium subverts the dominant ends of architecture or art by destabilizing them, but creative action is about possibility, more precisely the possibility of a possibility.

To conclude, then, there is a direct connection between the virtual, the visual, and the social. In order to solve actual pragmatic problems, design fields must continually explore, test, and innovate. In modern culture, buildings, as products, became valued for exchange; even so-called public or civic buildings are constructed in order to promote tourism and trade. If, as Deleuze observed, "Every epoch is defined by its own practices of knowledge and strategies of power, which are composed from regimes of visibility and procedures of expression,"[12] then it is my intention to draw attention to the possibility that architecture, through its process of creation (imaging), could have an existence outside a system of commodity. Experimental design methods, while their future benefits are still unknown, provide a means of furthering the imagination, so that through the very public nature of media (and their attendant modes of text, whether books or periodicals, photographic images, competitions, films, videos, or websites) architectural ideas could be said to have found a free public expression, a noncommodified existence, to which architecture as public space may make a traditional claim. Perhaps this immaterial, non-regulated public face or forum has the potential to ultimately contribute towards social change as well.

Notes

Chapter 1
Architecture + abstraction

1 Peter Zellner, *Hybrid Space: New Forms in Digital Architecture* (London: Thames & Hudson), 13.

2 Paul Virilio, *The Vision Machine* (Bloomington, IN: Indiana Press, 1994), 29.

3 David T. Runia, *The Philo of the Timaeus of Plato* (Leiden: E. J. Brill, 1986).

4 Martin Heidegger, *Being and Time,* trans. Joan Stambaugh (Albany, NY: State University of New York Press, 1996).

5 Roland Barthes, *Camera Lucida: Reflections on Photography* (New York: Hill and Wang, 1981), 94.

6 Robin Evans, *Translations from Drawing to Building and Other Essays* (Cambridge, MA: MIT Press, 1997), 163.

7 Marshall McLuhan, *The Essential McLuhan: The Medium is the Message* (New York: Basic Books, 1995).

8 Gilles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* (Minneapolis, MN: University of Michigan Press: 1987), 13.

9 Le Corbusier, *Towards a New Architecture* (New York: Payson and Clark Ltd, 1927), 134-135.

10 Lars Spuybroek, "The Weight of the Image" (4th International Summer Master Class, Netherlands Architecture Institute: Rotterdam, 1999), 3.

11 Sanford Kwinter, *Architectures of Time: Toward a Theory of the Event in Modernist Culture* (Cambridge, MA: MIT Press, 2002), 29–31.

12 Manuel DeLanda, "Philosophies of Design: The Case of Modelling Software," in Jaime Salazar, Albert Ferre, Manuel Gausa, Ramon Prat, Tomoko Sakamoto and Anna Tetas (eds), *Verb Architecture Boogazine: Authorship and Information*, No 1 (Madrid: Actar Press, 2002).

13 Horst Rittle, and M. Webber, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4, 2 (1973): 162.

14 Donald W. McKinnon, "The Creativity of Architects," in Taylor (ed.) *Widening Horizons in Creativity* (Hoboken, NJ: John Wiley & Sons, 1964), 2.

15 Felipe R. Gutterriez, "The Theory and Practice of Reading and Interpretation" (Rhetoric seminar 181, University of California, Berkeley, CA, Spring 2004).

16 Walter Benjamin, "On Language as Such and on the Language of Man," in *Selected Writings 1913–1926,* 4 vols. (Cambridge, MA: The Belknap Press, 1996), 62.

17 Gilles Deleuze, *Bergsonism*, trans. Hugh Tomlinson and Barbara Habberjam (New York: Zone Books, 1991).

18 Samuel Weber, "The Virtuality of the Media," *Emergences: Journal for the Study of Media* 10 (2000): 37.

19 Pierre Levy, *Becoming Virtual: Reality in the Digital Age* (New York: Plenum Pub. Corp., 1998).

20 Manuel DeLanda, *A Thousand Years of Non-Linear History* (Brooklyn NY: Zone Books, 1997) p259-261.

21 The term "use-value" has a long history outside of the arts, primarily with Marxist economic theory. Here the term is used in its limited sense.

22 Bernard Cache, *Earth Moves: The Furnishing of Territories,* ed. Michael Speaks, trans. Anne Boyman (Cambridge, MA: MIT Press, 1995), xv.

Chapter 2
Architectural modes of seeing

1 Spiro Kostof, *A History of Architecture: Settings and Rituals,* 2nd ed. (Oxford: Oxford University Press, 1995).

2 Nicholas Mirzoeff (ed.) *The Visual Culture Reader,* 2nd ed (New York: Routledge, 2003).

3 Rob Shields, *The Virtual* (New York: Routledge, 2003), 5–6.

4 J. L. Heilbron, *The Sun in the Church: Cathedrals as Solar Observatories* (Cambridge, MA: Harvard University Press, 1999).

5 Mitchell Schwarzer, "Perceptions" (seminar on Visual Criticism, California College of the Arts, San Francisco, CA, Fall 2002).

6 J. M. Hillis, M. O. Ernst, M. S. Bank and M. S. Landy, "Combining Sensory Information: Mandatory Fusion within, but not between Senses," *Science,* Nov. 22, 2002: 1627 <http://www.Berkeley.edu/news/media/releases/2002/11/21_brain.html>

7 John R. Searle, *Mind: A Brief Introduction* (Oxford and New York: Oxford University Press, 2004).

8 Christopher Bobonich, *Plato's Utopia Recast: His Later Ethics and Politics* (Oxford: Clarendon Press; New York: Oxford University Press, 2002).

9 Ibid.

10 Schwarzer, "Perceptions."

11 Linguists claim that naming is knowing; the social and cultural perception of *architecture* was originally associated with the physical body and secondarily with agriculture, specifically with the bodies of animals. The Latin root word *armus,* from which the term architecture derived, carries the meaning "the side or skeleton of an animal." Its origin also had associations with violence and physical force, *armatus* being the root for both weapons and armor worn in war, as well as for building tools. The word architect came into use at a much later date and distanced the profession from its agricultural

and military past, although it remained decidedly related to physical labor: Fr., Gr. *Architekton* chief artificer or craftsman, master builder; Fr *archi+tekton*: workman (Oxford Dictionary).

12 Barry Katz, *Technology and Culture: A Historical Romance* (Stanford, CA: Stanford Alumni Assoc., 1990), 34. It has been documented in a number of other sources that Greek slaves were imported to design and construct Roman public buildings during the second century BC.

13 Schwarzer, "Perceptions."

14 Jonathan Crary has already written extensively on the subject. For further information, refer to Crary, Jonathan, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, MA: MIT Press, 1999).

15 Jonathan Crary and Hal Foster have also considered the social significance of this shift during the Renaissance; it is frequently construed as a reaction against the primacy of the predominantly Christian hierarchy, whose political-religious influence was pictorially represented by Byzantine flattened space. In otherworldly medieval paintings, size was related to divine importance or hierarchy instead of perceived location in space. Thus perspectivalism resulted in a lessening of the discursive or narrative function of both architecture and painting. Medieval cathedral walls and later theatrical prosceniums were painted with frescoes that operated as image-based narratives for the illiterate masses. Functioning as mnemonic devices, they were a form of pictograph or iconography, and through them knowledge became spatialized. Buildings containing such frescoes or mosaics were literally a repository of knowledge. It was only later, during the Renaissance, that paintings became detached from walls, decontextualized and secularized. Removed from their original context, they could be bought and sold in an exchange system as commodities. The result was that the world narrative was no longer read as divine imagery existing in a communal space/time, but as a rational, non-contextual, ordered mathematical system that could be dispassionately viewed by a neutral observer.

16 Leon Battista Alberti, *Della Pictura,* trans. John R. Spencer (New Haven, CT: 1956), 43–59; *On the Art of Building,* trans. Joseph Rykwert, Neil Leach, and Robert Tavernor (Cambridge, MA: MIT Press, 1988), 2–9, 23–4.

17 For further information on Renaissance perspective linked to the mathematics of depiction, please refer to <http://graphics.csail.mit.edu/~fredo/ArtAndScienceOfDepiction/14_Perspective/perspective6bw.pdf>

18 Schwarzer, "Perceptions."

Chapter 3
Formulating abstraction

1 Bernardo Bertolucci, *The Dreamers*, interview, National Public Radio, Morning Edition, February 6, 2004. Refer also to <http://en.wikipedia.org/wiki/May_1968#Slogans_and_graffiti>

2 Lucy R. Leppard, *Six Years: The Dematerialization of the Art Object from 1966 to 1972* (Los Angeles: University of California Press, 1973).

3 Richard Flood, and Francis Morris, *Zero to Infinity: Arte Povera 1962–1972,* exhibition catalogue (London: Tate Museum of Modern Art, 2001).

4 Pierre De Meuron, interview with Therese Tierney, Basel, Switzerland, July 14, 2001.

5 Joshua Reynolds, *Discourses on Art,* ed. Robert R. Wark (San Marino, CA: Huntington Library, 1959).

6 The principles of art's universal subjectivity were later codified in Immanuel Kant's "On the Ideal of Beauty," from *Critique of Judgement* (first published 1790), Werner S. Plucher, trans. Indiananpolis, IN: Hackett, 1987 and eventually find their way into Greenberg's thinking.

7 Gotthold Ephraim Lessing, *Laokoon: An Essay upon the Limits of Painting and Poetry*, trans. Ellen Frothingham, (New York: The Noonday Press, 1957), 91-92.

8 Clement Greenberg, "Towards a Newer Laokoon," *Partisan Review* 7, no. 4 (July–Aug 1940): 305.

9 Shannon Jackson, Charles Altieri and Whitney Davis, "Theory Across the Arts" (Rhetoric lecture 240G, University of California, Berkeley, CA, Fall 2003).

10 Sir John Summerson, *The Classical Language of Architecture* (Cambridge, MA: The MIT Press,1966).

11 An exception to this was the Bauhaus under Walter Gropius's direction. His manifesto called for a unification of all the arts, including performance and theatre, "in a cathedral of socialism."

12 Le Corbusier, *Towards a New Architecture*, trans. Frederick Etchells (New York: Payson and Clark Ltd, 1927), 65–83.

13 The questions that the Surrealists asked during the 1920s and 1930s were revisited during the 1960s and 1970s. Although the architectural discourse was not especially engaged with topics related to doubling, media presentations, or the origins of transmedia art, other artists were.

14 While many architects—CIAM, the Situationists—were concerned with social and economic equality after the war, most of their efforts centered on the issue of mass or social housing alone, because of a manufacturing drive spurred on by production during and after the war. For many architects, it was difficult to separate mass culture from the goal of standardization, which was believed to be the only practical economic strategy to accomplish social justice. And even these efforts were primarily confined to Europe, as the majority of American architects were in the midst of a post World War II building boom and normative building practices.

15 Whitney Chadwick, (ed.) *Mirror Images: Women, Surrealism and Representation* (Cambridge, MA: MIT Press, 1998), 5.

16 Flood and Morris, *Zero to Infinity*, p. 24.

17 Peter Eisenman doesn't make distinctions between the art process and the architectural process (though he does in the product). Eisenman, Peter, "Conceptual Architecture: Towards a Definition," *A+U*, 2 (Feb 2001): 365.

18 Leppard, *Six Years*, p. viii

19 Greenberg, "Towards a Newer Laokoon," p. 301.

20 Through his writings, Greenberg promoted abstract expressionism via the gallery system, inadvertently or perhaps intentionally inflating the value of his own art collection.

21 Edward A. Shanken, "Art in the Information Age: Technology and Conceptual Art," *Leonardo* 35, 2 (2002): 433.

22 Flood and Morris, *Zero to Infinity,* p. 16.

23 *Zero to Infinity: Arte Povera 1962–1972,* exhibition (Museum of Contemporary Art, Los Angeles, CA, 10 Mar–11 Aug 2002).

24 Flood and Morris, *Zero to Infinity,* p. 17.

25 Wilfried Wang, *Herzog & de Meuron* (Basel: Birkhauser Verlag, 1992), 191.

26 Germano Celant, *Arte Povera* (New York: Praeger, 1969), 179.

27 Jean-Pierre Protzen, "Design Theories and Methods" (architecture lecture, Arch 230, University of California, Berkeley, CA, Spring 2003).

28 Shanken, "Art in the Information Age," p. 433.

29 De Meuron, interview.

30 Samuel Wagstaff, Jr. "Talking with Tony Smith," in Gregory Battcock (ed.) *Minimal Art: A Critical Anthology* (New York: Dutton, 1968). Tony Smith was educated as and practiced as an architect.

31 Ibid., p. 19.

32 Shanken, "Art in the Information Age."

33 Eleanor Rosch, "If you depict a bird, give it space to fly: Eastern Psychologies, the Arts, and Self-knowledge," *SubStance: A Review of Theory and Literary Criticism*, 30, nos. 1 and 2001 p236-51.

Chapter 4
Mapping absence

1 Georges Bataille and Isabelle Waldberg, eds., and Iain White, *Encyclopaedia Acephalica: Comprising the Critical Dictionary and Related Texts* (London: Atlas Press, 1996).

2 Conversation with Jay Baldwin, California College of the Arts, San Francisco, CA, March 28, 2006. Bucky also claimed that humanity faces the imminence of either utopia or oblivion, to be decided by the degree of spontaneous cooperative effort to make the world work for everyone.

3 British Council Design museum <http://www.designmuseum.org/design/index.php?id=92>.

4 Uros Cvoro, "The Present Body, the Absent Body, and the Formless – Public Sculpture by Rachel Whiteread," *Art Journal*, Winter, 2002.

5 "Le Travail de l'informe: Functions of Formless" (symposium, University College Cork, 2002).

6 Mark Wigley, "Jacques Derrida: Invitation to a Discussion" (lecture interview, Columbia University, Sept 27, 1992), 8.

7 Jacques Derrida, "Différance (1968)," in *A Critical and Cultural Reader,* ed. Anthony Easthope and Kate McGowan (Toronto: University of Toronto Press, 1992).

8 Rosalind Krauss, "Sculpture in the Expanded Field," 18

9 Stan Allen, *Points+Lines: Diagrams and Projects for the City* (New York: Princeton Architectural Press, 1999) 92.

10 Jacques Derrida, *Of Grammatology,* trans. Gayar Chakravorty Spivak (Baltimore, MD: Johns Hopkins University Press, 1976).

11 Anne Boyman, trans. Michael Speaks (ed.) Bernard Cache *"Earth Moves: The Furnishing of Territories"* (Cambridge, MIT Press, 1995. pviii)

12 Gyorgy Kepes, "Art and Ecological Consciousness," in Gyorgy Kepes (ed.) *Arts of the Environment*, (New York: George Braziller, 1972).

13 Toshiko Mori, "Class Notes," interview with Susan Szenasy, *Metropolis Magazine,* August 2003: 144.

14 Jean-Pierre Protzen, "Design Theories and Methods" (architecture lecture, University of California, Berkeley, CA, Spring 2004).

15 Definitions: "A bite is a combination of 8 bits. Each bit contains either a 0 or a 1, so that is has either one of two possible states. Each of the two digits stands for a tetrad (also: a nybble) of a byte, i.e. 4 bits. 1 tetrad is enough to represent any number" (cf. Fleischmann 1994). A nibble is four bits or half of a byte.

Minor media is a term that follows Félix Guattari's conception of art and new media towards *heterogeneous machines*, which are obligatory to link people together.

16 Deleuze, *Bergsonism*, pp. 31–32.

17 Margarete Jahrmann, <http://www.climax.at/nybble-engine-toolz/2005/>

18 Ibid.

19 Ibid.

20 Anne Boyman, trans. Michael Speaks (ed.) Bernard Cache, *Earth Moves: The Furnishing of Territories* (Cambridge, MA: MIT Press, 1995).

21 Paul Marino, (Comparative Media Studies colloquium, Massachusetts Institute of Technology, Fall 2005).

22 Edward Shanken, correspondence, April 15, 2006.

23 Heinz Von Foerster, *Understanding Understanding: Essays on Cybernetics and Cognition* (New York, NY: Springer, 2002).

24 Noam Chomsky, *Media Control* (Seven Stories Press, 2002).

25 Parts of the following reflections on *mediapoiesis* (a specific code expression that becomes visible while executed) are published in the jury statement for *Software Art* at the Transmediale Berlin 2003, in cooperation with the artists Amy Alexander and David Rokeby.

A computer program's text is generally hidden, interpreted by the processor, operating system and hardware before being presented to the audience. But the inaccessibility of the program's source code does not make the code-text itself culturally irrelevant …

A conceptual framework that allows one to discuss software-related issues without descending to implementation specifics would be a valuable tool. But reading and understanding the code text itself is not enough. Such a framework or metalanguage must not be merely an abstract representation of code function and code structure, but also a way of talking about the ways that coding actions ripple out through executing machinery to affect the social context. An algorithm may be a simple representation of a mathematical or logical

equation. But even a simple and easily understood algorithm can be a provocative agent in the complex system of the world. Software defines processes, which reflect and transform the complex world that surrounds them. An algorithm can be thought of as a person's way of making sense out of data. Code transforms the significance of data, and the data that code is applied to changes the significance of the code. They form contexts for each other. Artists and corporations often process the same data through very different kinds of algorithms bringing radically different interpretations of the data. Choosing to put an algorithm into play in the world is an expressive decision that cannot and must not hide behind the apparent objectivity and "innocence" of the algorithm as an isolated logical entity.

26 Sergio Lopez-Piñeiro, (lecture at University of California, Berkeley, CA, Summer 2004; Master's thesis completed at Princeton).

Chapter 5
Generative systems

1 Jean-Pierre Protzen, (Architecture lecture 230, University of California, Berkeley, CA, Spring 2003).

2 Therese Tierney, (research at Massachusetts Institute of Technology Media Laboratory, Spring 2005).

3 Marcus Schein, "Applied Generative Procedures in Furniture Design," in Celestino Soddu (ed.) *Proceedings of the 5th International Conference GA*, (Generative Design Lab, DIAP Politectnico di Milano University, 2002), 2.

4 To a certain degree, any method will always shape the results. Humans are adaptive, and after methods are mastered they fall into the background, operating unconsciously (John Searle, *Construction of Social Reality*, 1995, p127–147).

5 Michael Speaks, "Intelligence after Theory," *Network Practice* (New York: Princeton Architectural Press, forthcoming 2007).

6 Manuel DeLanda's "Genetic Algorithms," in *AD: Architectural Design,* and Greg Lynn's "Geometry in Time," in *Anyhow* ed. Cynthia Davidson, 1998, are two exceptions among others.

7 Vinod Goel, "A Cognitive Science Analysis of Designers' Representations," in *Sketches of Thought* (Cambridge, MA: MIT Press, 1995), 127.

8 Horst Rittle, "Dilemmas in a General Theory of Planning," *Policy Sciences* 4 (1969): 161–166.

9 Goel, "A Cognitive Science Analysis," 151.

10 Michael Benedikt, *Cyberspace: First Steps* (Cambridge, MA: MIT Press, 1991), 19.

11 In addition, the majority of programmers are neither artists nor architects. While this is changing through research and development at third-level institutions—Carnegie Mellon, ETH Zurich, MIT Media Labs, UC Berkeley, UCLA, University of Michigan—typically, most software programs are still designed by engineers.

12 Horst Rittel, "On the Planning Crisis," *Bedrifts Okonomen* 8 (Oct. 1972): 22; Schön, Donald A., *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983), 40.

13 Peter Bentley, "Evolutionary Design by Computers" (San Francisco, CA: Morgan Kaufmann Pub, Inc.,1999), 35. Paper presented at CODE: the Language of our Time (Ars Electronica, Linz, Austria, 2003).

14 Schein, Marcus, "Applied Generative Procedures in Furniture Design", in Celestino Soddu *Generative Design Lab*, DIAP Politectnico di Milano University (Mailand: Alea Design Publisher, 2003), 191–201.

15 Marcus Schein, "Evolutionary Computer Generated Design: A Methodical Approach from a Designer's Point of View," ed. Gunnar Johannsen (8th IFAC-Symposium on Analysis, Design and Evaluation of Human Machine Systems, VDI/VDE-GDA for IFAC, Kassel, 2001), 5.

16 Tom Ritchey, *General Morphological Analysis: A General Method for Non-Quantified Modeling* (adapted from an article presented at the 16th EURO Conference on Operational Analysis, Brussels, 2002) <http://www.swemorph.com/ma.html>

17 Fritz Zwicky, *Discovery, Invention, Research through the Morphological Approach* (Toronto: Macmillan Co, 1969), p. 34.

18 "Emergence-Morphogenetic Design Strategies," in *AD: Architectural Design,* (London: Wiley Academy, 2006).

19 Benjamin Libet, *Mind Time: The Temporal Factor in Consciousness* (Cambridge: Harvard University Press, 2005).

20 Guenther Doerner, and Oliver Endemann, "Objecter: A Step towards a General Tool for Generative Design," in Celestino Soddu (ed.) *Proceedings of 6th International Conference Generative Art*, (Mailand: Alea Design Publisher, 2003), 11.

21 Christopher Hawthorne, "Shop Talk," *Metropolis Magazine*, May 2001 <http://www.metropolismag.com/html/content_0501/shp/index.html>

22 Kwinter, Sanford. interview. "The Genealogy of Models: The Hammer and the Song" OASE , no. 23 (1997) pp 31-43. Other proposals include D'arcy Thompson's On Growth and Form (1917) followed by Christopher Alexander who extended Thompson's parametric notion, "the form is the diagram of forces," into architecture. This line of thinking was further explored by John Frazer at the Architectural Association and later the Emergent Design Group at Massachusetts Institute of Technology.

23 Turning, Alan M. "The Chemical Basis of Morphogenesis", in *Philosophical Transactions of the Royal Society of London*, Series B237 (1952) 37-72.

24 <http://plato.stanford.edu/entries/turing/>

25 Kwinter, "The Genealogy of Models."

26 Peter Testa, Ph.D. Principal, TESTA Architecture/Design, Emergent Design Group, MIT, email correspondence, Dec. 12, 2004.

27 *Poiesis of Spaces: KTH Codes and Architecture.* KTH school of Architecture <http://www.arch.kth.se/poiesis/>

28 Kwinter, "The Genealogy of Models."

Chapter 6
Formal matters

1 Giovanna Borradori, "The Metaphysics of Virtuality in Bergson and Nietzsche" (paper presented at the Fellows Seminar,

The Italian Academy for Advanced Studies, Columbia University, New York, September 15, 1999).

2 Elenore Rosch, (graduate seminar on Psychology of Narrative Formation, University of California, Berkeley, CA, Fall 2002).

3 Michel Foucault, *The Order of Things: An Archeology of the Human Sciences* (New York: Vintage Books, 1966). It would be interesting to see what Foucault would venture about today's surveillance methods, since the panopticon is now everywhere.

4 Sanford Kwinter, "Emergence: or the Artificial Life of Space," in *Anywhere* (New York: Rizzoli, 1992),165.

5 Taylor, Frederick Winslow, *Shop Management, The Principles of Scientific Management and Testimony Before the Special House Committee* (New York: Harper & Row, 1911)

6 Kwinter, "Emergence"

7 This method of deriving spatial location by a system of coordinates is still used today by the military.

8 Brian Massumi, *Parables for the Virtual: Movement, Affect, Sensation* (Durham, NC: Duke University Press, 2002).

9 Gilles Deleuze, *Difference and Repetition*, trans. Paul Patton (New York: Columbia University Press, 1994), 56.

10 Kwinter, "Emergence."

11 Catherine Ingraham, "Lines and Linearity: Problems in Architectural Theory," in Andrea Kahn (ed.) *Drawing/Building/Text,* (New York: Princeton Architectural Press, 1991), 82.

12 The designer, as well as the design act, is also an event space, a nexus of an entire set of activities relating to self-formation. The notion of a changeable self or self-construction is especially fascinating in terms of morphogenesis or how internal formal structures inform or shape people's lives. Not only do Freud's theories articulate this notion but, specifically, Freud's 'Repeating, Remembering and Working out' is illustrative of a designer's iterative process towards a solution.

13 Albert Pisano, "Unwinding the Clock: Measures of Time and Art" (UCB Art Museum lecture, April 23, 2006).

14 Felipe Guttierrez, (Rhetoric 181 Honors Seminar, University of California, Berkeley, CA, Spring 2004).

15 Gilles Deleuze, *Bergsonism,* trans. Hugh Tomlinson and Barbara Habberjam (New York: Zone Books, 1991).

16 John R. Searle, *Intentionality* (Cambridge: Cambridge University Press, 1999).

17 Deleuze, *Bergsonism*.

18 Ben Milbourne, "Reflections of the Virtual: The Virtual in Architecture and the Potential of Animate Form," *Architecture Theory Review* 7, 2, 2002.

19 Walter Benjamin, "On Language as Such and on the Language of Man," in *Selected Writings 1913–1926* 4 vols. (Cambridge, MA: The Belknap Press, 1996).

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21 F. Sobels, (ed.) *Mutation Research* 2003 <http://www.mutationresearch.com/mutat/show>

22 Samuel Weber, "The Virtuality of the Media," *Emergences*, 10 (2000), 1: 38.23 Deleuze, *Difference and Repetition*, 57.

24 Brian Massumi suggests that writing itself is production. It is possible to extend this notion further to say that the act of reading is productive, in that it produces new thoughts.

25 Gerald Mendelson, (conversation at University of California, Berkeley, CA, November 16, 2004).

26 Jean-Pierre Protzen, (Architecture lecture, University of California, Berkeley, CA, Spring 2003).

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The status of the architectural image

1 Bernard Cache, *Earth Moves: the Furnishing of Territories* (Cambridge, MA: MIT Press, 1995), 3.

2 W.J.T. Mitchell, "Showing Seeing: A Critique of Visual Culture," in Nicholas Mirzoeff (ed.) *The Visual Culture Reader,* 2nd ed (London: Routledge, 2002).

3 Whitney Davis, *Pictoriality and Visuality* (New York: Oxford University Press, forthcoming).

4 Ibid.

5 Jacques Derrida, "Signature/Event/Context," in *Margins of Philosophy,* trans. Alan Bass (Chicago: University of Chicago Press, 1982).

6 Jean-Luc Nancy, "Why There Are Several Arts and Not Just One," in *The Muses,* trans. Peggy Kamuf (Stanford, CA: Stanford University Press, 1996).

7 Sergio Lopez-Piñeiro, (Master's thesis lecture, University of California, Berkeley, CA, Summer 2004).

8 Jean Baudrillard, *Selected Writings* (Stanford, CA: Stanford University Press, 1988).

9 Donald A. Schön, "From Technical Rationality to Reflection-in-Action," in *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983), 41.

10 Sanford Kwinter, "Emergence: or the Artificial Life of Space," in *Anywhere* (New York, 1992).

11 Nancy, "'Why There Are Several Arts," 37–38.

12 D. N. Rodowick, *Reading the Figural or Philosophy after New Media* (Durham, NC: Duke University Press, 2001), 128.

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2.7 Jan Vermeer The Painter and his Model as Klio (detail) (1666-1667)
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5.1 Joshua Dannenberg and Chris Schusta, Harvard Graduate School of Design

5.2 Joshua Dannenberg and Chris Schusta, Harvard Graduate School of Design

5.3 Achim Menges The Emergence and Design Group, Architectural Association Partner, Ocean North

5.4 Achim Menges The Emergence and Design Group Architectural Association Partner, Ocean North

5.5 Achim Menges The Emergence and Design Group Architectural Association Partner, Ocean North. Source: 'Emergence-Morphogenetic Design Strategies," in *AD* (London: Wiley Academy, 2004)

5.6 Edward J. B. Irving, *Aircraft Classified: Handbook of Simplified Data Relating to the Best-Known Allied and European Aircraft,* aka *Irving's Aircraft Recognition Handbook* (London: Harper)

5.7 Haresh Lalvani, Pratt Institute, New York, AlgoRhythm Technologies. Fabrication: Alex Kveton, Bruce Gitlin at Milgo-Bufkin Computer modeling: Neil Katz Photography: Robert Wrazen

5.8 Achim Menges, The Emergence and Design Group Architectural Association Partner, Ocean North

5.9 SCI-Arc 2GBX Studio Spring 2005 Software: GENR8 by Emergent Design Group/MIT

5.10 SCI-Arc 2GBX Studio Spring 2005 Software: GENR8 by Emergent Design Group/MIT

5.11 Toyo Ito architect Structural analysis/SAP diagram Sasaki Structural Consultants, Island City Central Opark GRIN GRIN in Fukuoka, 2005.

5.12 http://www.GenerativeArt.de

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6.3 Courtesy of the Bancroft Library, University of California, Berkeley

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7.1 Courtesy of Ramiro Diazgranados and Georgina Huljich

7.2 Courtesy of Ramiro Diazgranados and Georgina Huljich

7.3 Joshua Dannenberg and Chris Schusta: Metacity Lagos-Loop (2006). Harvard Graduate School of Design 2311, Fall 2005, Instructor: Kostas Terzidis

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